

TOP SCIENCE NEWS OF 2008

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The Man Who Can Erase Fear

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Handheld Wind Power

THE FUTURE NOW

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**THE RACE TO
HYPERSONIC
FLIGHT
HEATS UP**



**POPSI
COM**



JANUARY 2008

\$4.99



P.10

**3 WHEELS,
300
MILES PER GALLON**



P.28

**LIVING
GREEN
ON THE
MOON**

Sony HD Handycam® camcorder

The same minds behind the professional cameras used by nearly every sports network are behind the Sony HD Handycam® camcorders, bringing your memories the high-definition clarity and color they deserve.



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Requires HDMI connector (sold separately) and compatible BRAVIA TV. Full HD output requires compatible HDMI cable. Screen image simulated. *Requires compatible TV. Screen image simulated. Sony, Cyber-shot, Handycam, and HDMA are trademarks. Other names may be trademarks of their respective owners. © 2007 Sony Electronics Inc. All rights reserved. Screen image simulated.

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This One



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Jellyfish invasions, Internet auctions, god particles: Read about the year's biggest science stories before they happen. Bonus: How to decipher geeky jargon and when to buy a DeLorean.



CORBIS WASTEL/ET PROPELLSION LABORATORY; COURTESY SHANT USA; GREGORY G. DUNHAM/PHOTO RESEARCHERS; PETER BOLLINGER; ANDREW H. CORNELL; COURTESY MACE WINGBORO

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VIVA C.E.S.!

PopSci hits the Vegas strip and the Consumer Electronics Show to bring you complete coverage of the tech you'll be begging for this year. Robots! TVs! Robot TVs! From January 7 through 10 we'll be checking out gadgets around the clock, and so should you. Check out popsci.com/ces2008 for photo galleries, video from the show and more.

MORE DAILY NEWS!

► LUNAR LUXE

Peek inside a base station on the moon that's equipped with everything from gardens to studio apartments. See our conceptual animation of Luna Gaia at popsci.com/lunagaia.



THE BREAKDOWN

How can that guy scale a cliff in five minutes? What could make beer freeze that fast? Expand your mind when PopSci takes your favorite holy-crap, look-at-that YouTube videos and reveals their inner scientific workings at popsci.com/breakdown.



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AT PPX.POPSCI.COM

◀ PREDICTING '08

The top science stories of tomorrow are the ripe propositions of today. Will China figure out how to control the weather? Will NASA find life on Mars? Learn more on page 42, and then bet on the future at ppx.popsci.com.

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IF THIS IS YOUR IDEA OF A WIND TUNNEL, THIS MUST BE YOUR IDEA OF A TRUCK.

If you're the type who knocks the world down to size, you need a truck durable enough to help you do that. Ford F-150. It's got the strongest frame of any half-ton pickup. So it's not surprising Ford F-Series has more trucks on the road with 250,000 miles than any other brand.* Check it out at fordvehicles.com. '08 FORD F-150

*Based on vehicle registration data and latest odometer readings available to R. L. Polk & Co. for 1992 and newer model year full-line pickups still on the road in the U.S. as of 1/1/07.



Rock Hop

Thinking about a manned expedition to an asteroid seems a bit premature ["NASA's New Target," November 2007]. At present, NASA can't even send a manned expedition to the International Space Station at an acceptable level of safety or cost. The new Constellation vehicles will be an improvement, but if NASA ever wants to go beyond Earth's orbit, it will need to get over the idea of using a heavy-lift launch vehicle that can be flown only once. A lighter, reusable vehicle that stops in orbit to refuel before proceeding on to an asteroid or Mars could do much more for a small fraction of the cost.

Dick Morris

Lynnwood, Wash.

Steel Yourself

The "Burning Metal" experiment [How 2.0, Nov.], has practical applications. For years, I have carried in my "Montana winter survival kit" a nine-volt battery, some kindling and a small bag of fine steel wool. Tuck the steel under the kindling, touch the battery to it, blow on it, and presto—you'll have a fire almost instantly, even in windy conditions. Just make sure the steel wool and battery stay separated while you're walking!

Al Smith

Great Falls, Mont.

Author Theodore Gray replies:

This is indeed a great fire starter. But don't use a lithium battery, which can overheat and burst if shorted out.

Corrections

The credits in "Theoretical Plumber" ["The Brilliant 10," Nov.] should have attributed the top photograph to John Nikolai and the bottom image to Jeremy A. Levitan and Martin Bazant/MIT.

Because of a printing error, our article on HDMI 1.3 [December 2007] didn't properly illustrate the technology's effect. A "Before" image should have shown rings of color instead of appearing grainy.

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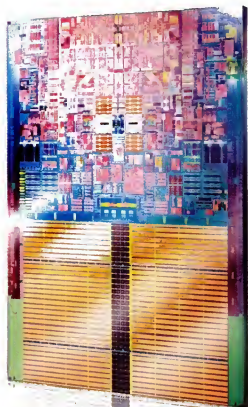
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MEGAPIXELS

THE MUST-SEE PHOTOS OF THE MONTH

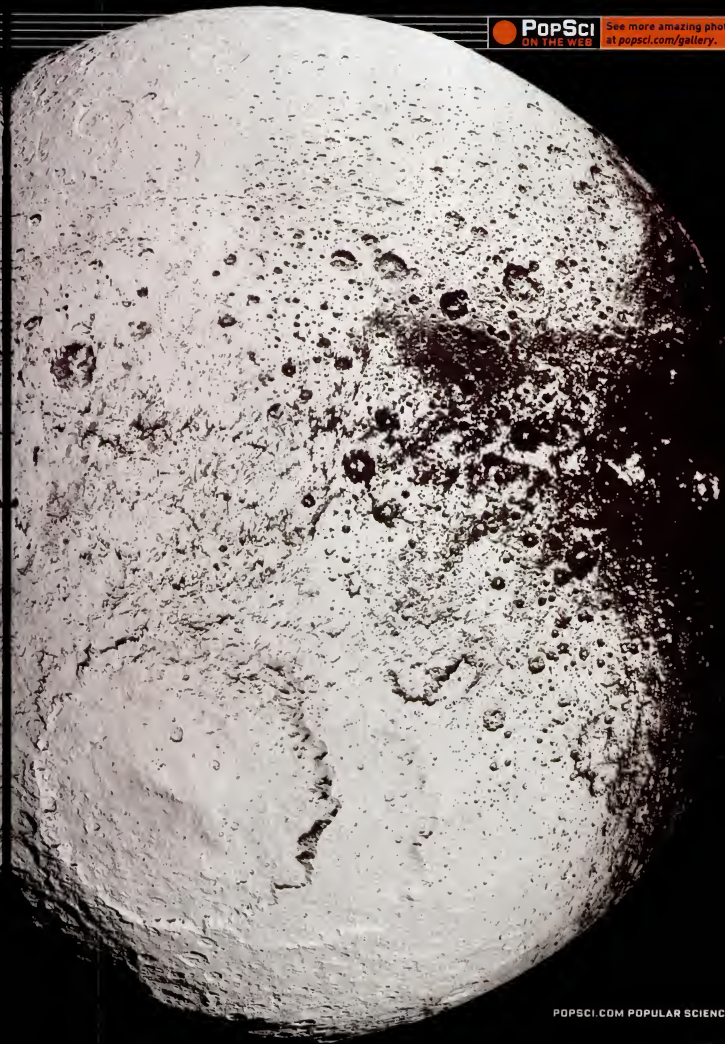
DARK SIDE OF THE MOON

A recent flyby of Saturn's moon Iapetus has helped scientists decode its startling two-toned surface

Situated 950 million miles from Earth, a bizarre walnut-shaped moon, Iapetus, makes its 79-day trip around Saturn. A recent flyby of the icy satellite by the spacecraft *Cassini* has garnered data and photos that help explain its patchy surface coloring. NASA scientists believe that the white parts of the moon are mostly bare ice, while on the black parts, the surface ice is blanketed with a fine dust that could come from another of Saturn's 60 moons. The yin-yang contrast is made more dramatic by a process called thermal segregation. When the dust-sprinkled side of Iapetus rotates into the sunlight, the ice under the dust on that side evaporates, leaving behind the concentrated dark debris. The water vapor then recondenses on the cold regions of the moon, heightening their snow-white appearance. *Cassini* is scheduled to study Saturn and its moons through at least the middle of 2010, checking out other sights like the water-vapor jets of Enceladus and the hydrocarbon seas that dot the surface of Titan. **BY SABA BERTHE**



COURTESY NASA/JUPITER SPACE INSTITUTE







DRIVING SAUCER

300 miles per gallon never looked so good

Five years ago, engineer Steve Fambro realized that up to 70 percent of the total energy it takes to power a vehicle goes into pushing the air in front of it out of the way. With that in mind, he stripped the car's exterior design of everything inessential and asked: What is the lowest-drag shape that can surround two occupants side by side? His answer is this teardrop-shaped three-wheeler, which has a drag coefficient of just 0.11. (In comparison, the eco-juggernaut Toyota Prius has a relatively parachute-like coefficient of 0.26.) High-strength composites drop the weight to approximately 1,400 pounds, and an electric motor combined with a one-cylinder engine powers the package. The resulting commuter pod, the Aptera, will wring 300 miles out of a gallon of ordinary gasoline. Once production starts late this year, prospective drivers might need a motorcycle license, approximately \$30,000, and a West Coast address—initially, the Aptera will be available only in California.

BY MATTHEW COKELEY

PHOTOGRAPHS BY AARON FELDMAN

KEEP ROLLIN' To protect passengers, the Aptera has a roll-cage design similar to F1 racers.



PULLING AWAY The Aptera goes from 0 to 60 in 10 seconds and tops out at 95 miles per hour.

Built for the urban wild.



A lockable In Bed Trunk. A dual-action tailgate. And the highest government crash-test rating. Solid proof the Ridgeline is perfectly designed to tackle your next urban adventure.

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Engines that burn less and churn more



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A homemade gadget-building kit



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Snowboard bindings that fit just right

INTERNET ALL OVER

With the arrival of the first WiMax devices, you can tap into high-speed access anywhere

THE DEATH KNELL for the wired Internet has sounded. WiMax, a new long-range wireless technology, will blanket cities and regions with wireless broadband Internet access when Sprint and Clearwire light up the first networks later this year. You'll pick up the signal at home with a modem like this Motorola CPEi 300; laptop adapters and WiMax-equipped cellphones will connect you on the go, even in speeding cars.

WiMax is more than just Wi-Fi on steroids. Wi-Fi uses unlicensed radio spectrum and must run low-power signals so that networks don't drown each other out. In contrast, Sprint and Clearwire own the parts of the 2.5-gigahertz spectrum that they will use for WiMax, so they can beam out stronger signals that span longer distances with no worries about interference.

As more coverage and gear roll out (Intel, Samsung and Motorola plan to release products this year), one WiMax account could get you online from several devices, anywhere in the country, no hot-spots or wires required.—GLENN FLEISHMAN

MOTOROLA CPEi 300

DIMENSIONS: 7 x 4 in.

RANGE: Up to 3 miles

SPEED: Up to 8 megabits per second

PRICE: To be determined by provider

GET INFO: motorola.com

▲ **CABLE KILLER** WiMax modems replace DSL or cable connections at home.



WHAT'S NEW



BACK BENDS

Standard stacking chairs can be stiffer than the conference-goers who sit in them. Not the Cinto. Its flexing seat back attaches to a stretchy elastomer belt instead of the chair's metal frame. **Humanscale Cinto** \$215; humanscale.com



FREE YOUR PHOTOS

Camera packed with old pictures? An SD card with built-in Wi-Fi not only stores two gigabytes of photos, but also automatically downloads them to your PC when it nears your home network.

Eye-Fi Card \$100; eye.fi

RUN WITH RHYTHM

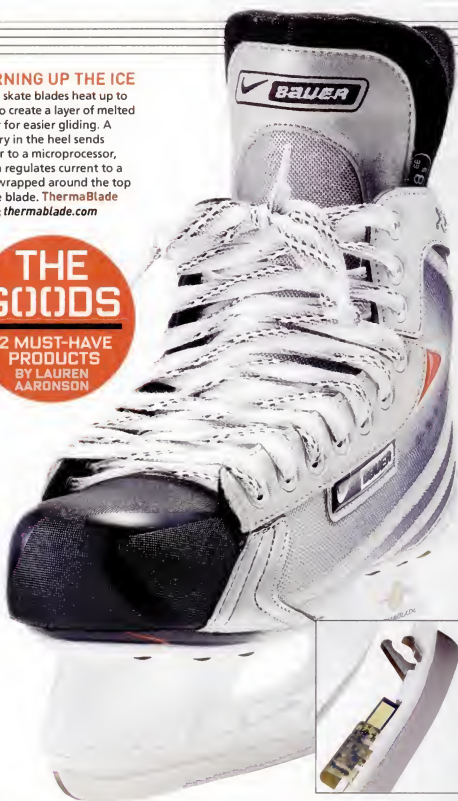
This MP3 player detects your jogging pace using an accelerometer and plays songs with matching tempos. (A PC program counts beats beforehand.) It also monitors your heart rate and mileage. **Yamaha BODiBEAT** \$300; bodibeat.com

BURNING UP THE ICE

These skate blades heat up to 41°F to create a layer of melted water for easier gliding. A battery in the heel sends power to a microprocessor, which regulates current to a wire wrapped around the top of the blade. **ThermaBlade** \$400; thermablade.com

THE GOODS

12 MUST-HAVE PRODUCTS
BY LAUREN AARONSON



NO STRINGS ATTACHED

Most ski poles make you wriggle your hand into a strap. But with LEKI's spring-loaded clasp, you simply click in a loop on compatible gloves or a strap-on grip. The clasp releases automatically during a fall. **LEKI Speed S** \$120; leki.com



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Windows Vista® Home Premium



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expert.**

When productivity matters, it's good to have an expert by your side. Wouldn't it be nice to get your work done more efficiently? Well, we can help. Just look at our Satellite® U305. It comes with Intel® Centrino® Duo processor technology and genuine Windows Vista® Home Premium, to breeze through those nasty bills and invoices. And starting at only 4.6 pounds¹ and with built-in Wi-Fi,² you can easily stay connected to whomever you want, whenever you want. Say 'hello' to a better way of doing business. www.toshiba.com/getitdone

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SHOW ON THE GO

Any USB TV tuner lets you watch shows on your computer. This one also records two hours of standard-def programs (or 30 minutes of high-def) to built-in flash memory, so you can take them with you. **Pinnacle PCTV HD Ultimate Stick \$130; pinnaclesys.com**

HIGH-DEF, LOW PROFILE

This 12-megapixel camera is one of the first point-and-shoots to capture high-definition (720p) video—its film clips rival a dedicated camcorder's. Just remember extra memory cards for the space-hogging HD files. **Kodak EasyShare V1253 \$300; kodak.com**



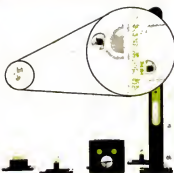
POCKET WINDMILL

The first palm-sized wind turbine can power a small gadget for an hour after 30 minutes of gusts. The blades' deep curve lets them turn a generator even in 9mph breezes. A battery stores energy from the turbine, a solar panel or a wall socket for later use. **HYmini From \$50; hymini.com**



DISASTER-PROOF YOUR DATA

The first fireproof and waterproof hard drive for the home is encased in the same concrete-based material used to insulate safes. Your data and all internal electronics can withstand 24 hours underwater or short bursts of 1,550°F. **SentrySafe Fire-Safe/Waterproof Hard Drive (80 GB) \$240; sentrysafe.com**



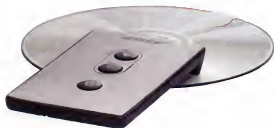
THE THRILL OF ATTRACTION

A magnetic roller-coaster kit sends metal balls through loops and other tricks. For a U-turn, magnets keep the ball firmly on a curve until it falls onto a track running in the other direction. **MEGA Brands Magnetix iCoaster \$80; megabrands.com**



DESKTOP DISCO

These mini computer speakers create booty-shaking bass without shaking themselves off your desk. Two speaker cones push low notes out slots on opposite sides of the cabinet, canceling out vibrations that cause some speakers to move around. **Bose Computer Music-Monitor \$400; bose.com**



TWIST AND SPOUT

This spray paint hits surfaces in a line, not the usual circle, and a dial lets you rotate the line to any angle. To cover a table leg in one downward swoop, say, twist the spray horizontally so it spans the entire width of the leg. **Krylon Paint with EZ Touch 360° From \$3; krylon.com**

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TECH
TREND

SHOTS IN THE DARK

New high-end cameras kill static to take crisper photos in low light

THE TREND

More digital cameras now use CMOS (complementary metal oxide semiconductor) sensors. Unlike earlier CCD (charge-coupled-device) chips, CMOS fits analog-to-digital conversion circuitry right on the sensor to reduce distortions known as "pixel noise"—colored flecks that occur at high light-sensitivity settings when the camera tries to brighten a dark image.

WHY NOW?

SLRs use large sensors to absorb more light than point-and-shoots. CMOS is becoming increasingly popular at these sizes because it consumes far less power than CCD.

THE BENEFIT

At dawn or dusk, you can photograph outdoor vistas that a camera flash can't possibly illuminate. Indoors, you'll capture scenes in natural light instead of the harsh, generic glow of flash.—DAN HAVLIK

THE DARK ARTS With megapixels in abundance, low-light performance is the new battleground for digital cameras, especially SLRs.



THREE CAMERAS WITH VIRTUAL NIGHT VISION

1. CANON EOS 40D

As the first company to use CMOS in SLRs, Canon sets the benchmark. Snapping up to 6.5 frames per second, the EOS 40D is one of the fastest semi-pro cameras. Its 10.1-megapixel shots of flowers at sundown were virtually noise-free at a relatively high setting of ISO 800. (The higher the ISO, the greater the light sensitivity.) Even at an extremely high ISO 3200, dimly lit portraits reproduced accurate skin tones. **\$1,300 (without lens); usa.canon.com**

2. SONY ALPHA A700

Sony's first model with CMOS took immaculate 12.2-megapixel photos of flowers at ISO 800, besting even the Canon. We could preview them on the camera's gorgeous three-inch LCD or on a high-def TV using the HDMI output. But at ISO 1600, overzealous noise-reduction software in the processor wiped out fine details. And at ISO 3200, our subject's skin had an artificially smooth, doll-like texture. **\$1,400 (without lens); sonystyle.com**

3. NIKON D3

This pro-grade camera's 12.1-megapixel sensor is about 2.5 times the size of Sony's and Canon's, letting it grab images in near pitch-black at an astounding ISO 25600. Images from a pre-production D3 at this level were sticky but revealed details that the naked eye can't see. Outdoor flower images were crisp all the way to ISO 3200, and indoor photos taken by candlelight at ISO 6400 showed surprisingly little noise. **\$5,000 (without lens); nikonusa.com**



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HOW IT WORKS

A SWITCH-HITTING ENGINE

Gasoline and diesel technologies merge for better mileage and less pollution

WITH ONLY A COMPACT 1.8-liter engine and a standard electric motor, Mercedes-Benz's F700 hybrid concept car nearly matches the horsepower of gas engines almost twice its size—and it gets 44 miles per gallon. That performance comes courtesy of a homogeneous charge compression ignition (HCCI) engine that combines the

power of a gas powerplant with the efficiency of a diesel.

The Mercedes starts and accelerates like a regular gas-fueled car. Spark plugs ignite a fuel-and-air mixture. But at highway speeds, it switches to HCCI. Compression and heat inside the cylinders cause ignition, mimicking a diesel engine, which uses high compression

to extract more energy from fuel. Best of all, HCCI engines can be designed for many fuels, including gasoline, natural gas, propane, ethanol, diesel and biodiesel.

Most carmakers are working on HCCI technology. Mercedes's version, called DiesOtto, could hit the streets in 7 to 10 years.—JARED AMADEO HOLSTEIN

HOW TO SQUEEZE MORE POWER FROM LESS FUEL

DiesOtto sips fuel like a diesel, revs like a gas engine, and runs cleaner than either of them

WHILE ACCELERATING, the DiesOtto operates like a regular gasoline engine: A spark ignites the fuel-air mixture, and a very hot flame spreads through the combustion chamber, driving the piston. To maximize power, a pair of turbochargers compress the incoming air, and an injector sprays extra fuel directly into the cylinder **[A]**.

HCCI kicks in for situations that don't require full power, such as freeway cruising. The throttle opens wide, allowing the engine to run with more

air and less fuel. The engine increases pressure in the combustion chambers by adjusting the opening and closing of the valves **[B]** and by using a chain-driven mechanism attached to the crankshaft to push the piston higher in the cylinder **[C]**.

Greater pressure causes the air-fuel mixture to self-ignite in multiple places for cooler, more uniform combustion. Lower temperature reduces the amount of energy lost to heat and prevents the production of nitrogen oxides, which are ingredients in smog.

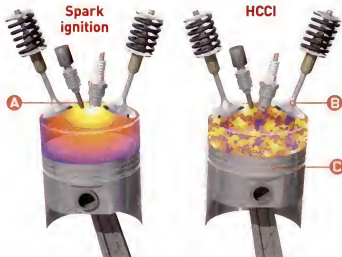


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COMING
SOON

GIZMO À LA CARTE

A do-it-yourself kit lets inventors build any widget, no factory required



FULL KIT Measuring 3 by 2.5 by 0.6 inches, the BUGbase [upper left] is a Linux computer with bays for up to four components, such as the GPS receiver, motion sensor, LCD screen and camera shown here.



SNAP TO IT To build a custom gadget, just snap modules onto the base.



IT'S EASY To dream up a new gadget, be it a better iPhone or something as frivolous as a TV that changes channels depending on the weather. BUG Labs wants to help you do something about it. In December, it began selling components that snap together to create new devices. To build that meteorologically aware TV, for example, you'd start with the BUGbase—the guts of a portable Linux com-

puter, including a processor, memory and Wi-Fi. Then plug in up to four modules, such as an LCD screen, a digital TV tuner and a miniature weather station with a barometer and thermometer. Finally, tell the components how to interact. You could write a program that takes data from the weather module and adjusts the TV tuner according to the rule, say, “Comedies on cloudy days; dramas on sunny days.”



UPGRADE IT Swap in forthcoming modules—including weather sensors, solar cells and HDTV tuners—to give your BUG new capabilities.

GET IT
Full kit set,
\$99.95. Not
available yet.

To create this snap-together system, engineers designed universal connectors that transmit power and data to any of the modules. And they embedded a chip in each module that allows the base to identify it. The project launched with a GPS receiver, touch-sensitive LCD screen, motion sensor and camera components. BUG Labs will add four new items every three months, based partly on user requests.

Initially, building a BUG will require programming skills. But the company hopes to go mainstream by encouraging coders to offer free or cheap programs so that less-techie designers can just copy them onto the device. The system could work for anything from one-off whimsical creations to prototypes of products that amateur designers can show investors. It puts the DIY in R&D.—SEAN CAPTAIN

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THE
SYSTEMEASIER
RIDER

A new snowboard binding technology lets you switch your stance on the fly

THE BEST WAY to stand on a snowboard depends on the rider atop the board and the terrain beneath. Burton's new Extra Sensory Technology (EST) binding lets you quickly dial in your perfect stance for downhill, terrain park or halfpipe.

Traditional bindings clamp to the board in a limited number of positions, through plastic disks that you often have to reattach when you adjust your stance. In Burton's system, each binding sits on two bolts that ride inside an aluminum channel. To raise

GET IT Burton EST bindings: \$300; compatible boards: \$530-\$550; burton.com

BURTON'S BETTER BINDING

the front of the board so that it "floats" over deep powder, for example, simply twist a screwdriver to loosen the bolts, slide your bindings toward the tail end, and tighten them with another twist. The bolts also rest in slots on the sides of the binding. You can rotate each foot up to 12 degrees inward or 27 degrees outward before locking it in.

To protect your feet, EST replaces the hard plastic binding mount with a shock-absorbing pad that bends with the board, so you feel more of the slope's contours but less of its hard bumps.—BERNE BROUDY

A. FOOT PAD In place of a hard plastic disk, the EST binding uses a half-inch-thick pad underfoot that absorbs slope smack after you catch air. (Your heel gets a gel pad for extra protection.)



B. WINDOWS With three indicators in the footbed that show your position on the board, you can quickly switch among favorite stances for dropping into the halfpipe or carving through powder.



C. SLIDING MOUNT Each binding locks onto bolts that slide in a channel, letting you easily adjust the width of your stance and your position on the board.



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MEDICINE

REBOOTING THE AIDS VACCINE

The booster was supposed to keep volunteers safe from HIV infection—but it failed. What now?

SEPTEMBER BROUGHT lousy news from the front lines of the fight against AIDS: In clinical trials, the most promising HIV vaccine in the pipeline failed to prevent infections. But researchers hope that tactical setbacks will deliver crucial insights. "We'd be a lot happier if we were looking at why it *did* work," says University of Washington AIDS researcher Lawrence Corey. "but we can learn a lot from why it didn't."

The most important—and disturbing—lesson from the trial may turn out to be that the vaccine made things worse. The September tally showed that volunteers who received the vaccine were slightly more likely to become infected than were those who got dummy shots. The difference was so small that it could have been coincidence, says Corey, who heads the International HIV Vaccine Trials Network, a consortium of AIDS researchers. But that possibility won't become clearer until more data rolls in.

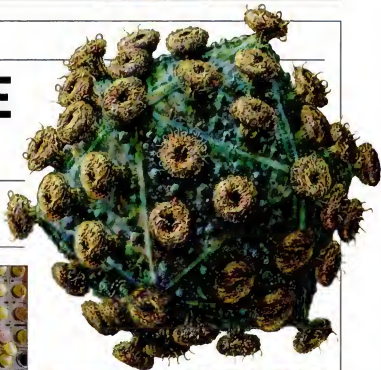
Naturally, researchers had hoped for better. In 2004, the pharmaceutical giant Merck and the National Institute of Allergy and Infectious Diseases (NIAID) began enrolling high-risk volunteers (mostly gay men) to receive a new kind of vaccine. Unlike standard vaccines, it was not designed to generate antibodies. Antibodies are immune chemicals that match telltale mark-



QUICK-CHANGE ARTIST HIV evades vaccines and drugs [above] by mutating its protein-studded envelope. The result is 39.5 million infections worldwide, and climbing.

ers, or antigens, on a foreign invader. But if antibodies are bounty hunters, then HIV is a master of ever-changing disguises. HIV mutates too quickly to be caught by antibodies.

So scientists came up with a clever new tactic. They designed a vaccine that uses a harmless cold virus to slip HIV genes into cells in the body. Instead of antibodies, this produces an army of immune cells primed to destroy HIV-infected cells. In theory, these "killer T cells" should reduce the number of infected cells to the point where HIV can't gain a foothold. Even if the vaccine failed to prevent infec-



tion, it should lower the viral load—the amount of HIV in the body—thereby slowing the progression to AIDS.

In tests on monkeys, the vaccine did just that, both reducing infection rates and lowering the viral load in those that became infected. Unfortunately, it did neither in the first 741 human volunteers to receive the vaccine: 24 became infected, compared with 21 out of 762 who got a dummy shot. More discouraging, the

CLOCKWISE FROM TOP RIGHT: RUSSELL NG/GETTY PHOTO RESEARCHERS; HUDSON AR/UNIVERSITY OF WASHINGTON; ADRIAN LUTZ/REUTERS

SPACE

THE GREEN SIDE OF THE MOON

Scientists design a self-sustaining lunar habitat that would make Al Gore proud

ASTRONAUTS will probably miss out on the luxurious quarters and gourmet meals planned for space tourists, but moon living may be cushier than expected. Luna Gaia, a habitat designed by an international team of scientists, engineers and graduate students, provides up to a dozen astronauts with fresh vegetables, fish, spacious rooms and clean drinking water (albeit recycled from their own urine).

The group designed the self-sustaining habitat, which harvests solar energy and reuses all of its waste, while attending the summerlong Space Studies Program at the International Space University in Strasbourg, France. Now, with interest in the moon accelerating thanks to NASA's focus and Google's new Lunar X Prize, Luna Gaia is proving to be more than just an academic exercise. In the past year, the team has presented the plan to several space programs, including NASA, which may incorporate ideas from Luna Gaia into its own lunar outpost, planned for sometime after 2020. "It's a really good stepping-stone toward designing an outpost on the moon," says William Marshall, a physicist at NASA's Ames Research Center.

According to the plans, Luna Gaia will be a complex divided into linked, studio-apartment-size pods. Situated in a crater to limit its inhabitants' exposure to solar radiation, it would include private and social areas, labs and exercise rooms, and greenhouses in which astronauts could grow the food necessary for a balanced diet. Filters, plants and bacteria will turn wash water and urine into potable water. Algae and other greenery turn carbon dioxide into oxygen. Overall, the group estimates, these systems would make Luna Gaia 90 to 95 percent sustainable, meaning fewer service trips, longer visits and a clearer conscience. —GREGORY MONE

6 STEPS TO CLEAN LUNAR LIVING

FIND A BIG CRATER

Designs call for Luna Gaia to be built in a mile-wide crater near the moon's north pole. The crater wall casts a shadow that protects the astronauts from solar radiation.

GO SOLAR

A dozen mirrors, each 100 feet wide, sit on top of the crater's rim, an area that's nearly constantly bathed in sunlight. These direct light onto another set of mirrors that focus the beam on a water supply, creating steam that drives a turbine and generates electricity for the base.

INFLATE YOUR BEDROOM

Luna Gaia will consist of several inflatable modules made of Vectran, a flexible material that's more durable than Kevlar and can be compressed in transit to help keep delivery costs down. The greenhouses will be transparent, but living quarters will be covered with a layer of regolith, or lunar soil, to provide added protection from radiation.

GO FISHING

Tilapia are high in protein and thrive in a crowded tank. Astronauts will also dine on hydroponically grown wheat and a variety of vegetables, such as spinach and potatoes. The same algae that cleans up the crew's water will be a good source of protein.

URINATE OFTEN

Urine runs first through an ion-exchange filter that removes some contaminants and then into the algae tanks, where the algae drink it up and release water vapor that a condenser liquifies. This water either runs back to the crew quarters for washing or is further purified to make it drinkable.

REUSE EVERYTHING

Several different strains of bacteria break down feces into water, minerals and ammonium. These materials are converted into nutrient-rich fertilizer and pumped into the plant, fish and algae chambers.

researchers found no difference in viral load between the two groups.

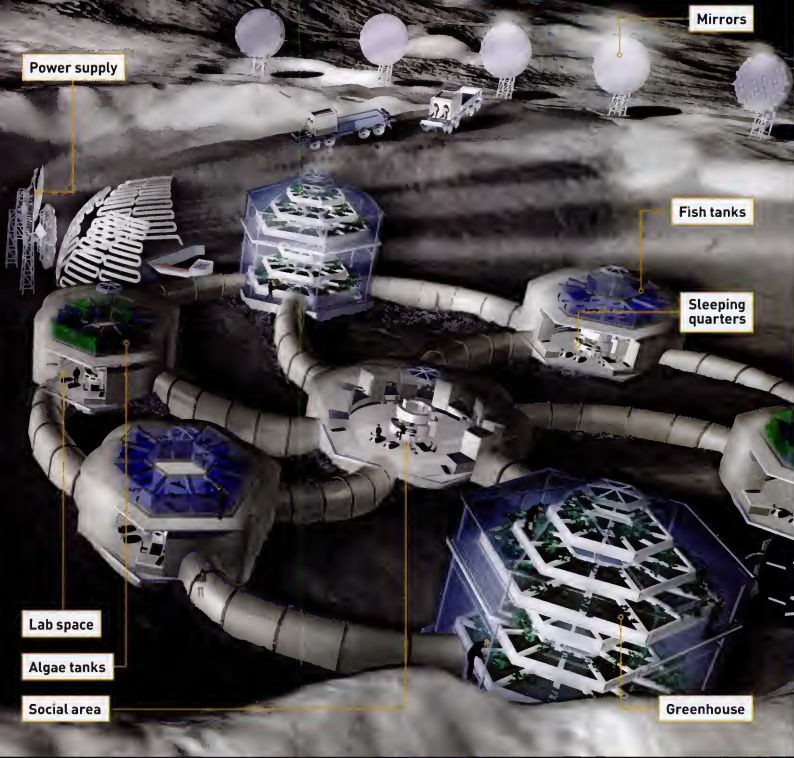
"The question now is whether this was a product failure or a concept failure," says NIAID director Anthony Fauci. "We know this vaccine didn't work. But did it fail because T-cell vaccines don't work?"

One theory lays blame on the weakened cold virus used to deliver HIV genes to human

cells. Most people have at least partial immunity to cold viruses. So the volunteers' immune systems may have snuffed out the modified virus before it could do its job. Or, Fauci notes, this carrier virus may have itself prompted an unhelpful response by calling forth the "helper" T cells that HIV loves to infect.

Yet another possibility is that the HIV genes used in the vaccine proved a poor

match for the HIV strains that infected the volunteers. If so, researchers could simply rejigger the vaccine with more or different genes. The worst-case scenario would be that the response produced by the vaccine matched the infecting strains yet still failed to stop them. "Then we'll have to reexamine why T cells were not as effective as we thought they would be," Corey admits.



The new AIDS vaccine prompts cautious optimism. Says Fauci, "I don't want to use the word 'promising.'"

While researchers continue to parse the failed trial, they are optimistic about the next HIV vaccine trial. Called PAVE 100, the trial will employ a "prime-boost" strategy. Before volunteers receive a modified cold virus similar to the one used in the previous trial, they will get a jab of HIV genes, with the purpose of priming their immune systems for a stron-

ger killer-T-cell attack. Plans call for the trial to enroll 8,500 volunteers in the U.S., Latin America, the Caribbean and Africa.

Fauci remains upbeat but cautious. "I don't want to use the word 'promising,' " he says of the upcoming trial. "This last one was called 'the most promising,' and see what happened."—JESSICA SNYDER SACHS

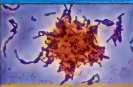
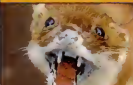



HEALTH

THE ACCIDENTAL TERRORISTS

Research on deadly germs is booming, and so are safety slipups. How worried should you be?

PLAGUE-INFECTED MONKEYS, sharp-toothed ferrets with bird flu that bite, broken vials of an exotic Russian virus that causes brain swelling: If you thought the anthrax letters that killed two postal workers in 2001 were scary, consider this latest string of botched biodefense experiments. In October, an Associated Press investigation turned up unpublished documentation of the mishaps, along with 100 or so other accidents involving deadly germs in the nation's biodefense laboratories since 2003. In the same month, a congressional report on biodefense concluded that safety oversights in such laboratories are dangerously slack. Details of the accidents are scarce, because much

of the work with "select agents"—about 70 germs ranging from anthrax and Ebola to "lumpy skin disease"—is classified. But one thing is certain: Biodefense research is exploding. Federal funds topped \$5.1 billion last year, up from \$576 million in 2001, and the number of labs approved to handle the deadliest germs has jumped from five to 15 since 2001. Ed Hammond, director of the Sunshine Project, a watchdog group that monitors bioweapons research, says that although there's a low risk of these bugs escaping the lab, the consequences of such a mishap could be catastrophic. Here, a look at rogue germs in captivity and why we hope they stay that way. —SUSAN MCCARTHY

HMM, WHAT'S THIS?	UH-OH.	OOPS!	PANIC?	
 ANTHRAX	A bacterium that can cause flu-like symptoms and black lesions on the skin. Inhaling anthrax causes death in 50 percent of cases.	Weaponized anthrax is highly lethal, and its spores are tough to kill.	May 2004: A research hospital in California receives live anthrax instead of dead samples. No one notices until mice begin dying.	No. The lab bungle caused no human infections. Even if it did, anthrax is treatable and doesn't spread from person to person.
 BIRD FLU	A highly infectious virus in birds. Human cases are rare but deadly, with a 50 percent mortality rate.	A few mutations could lead to a global pandemic in humans.	July 2007: An infected ferret bites a lab worker at a biological research firm in Rockville, Md.	Maybe. The bitten lab worker never became sick, but slipups of this kind could speed up bird flu's ability to infect humans.
 PLAGUE	A bacterium that transmits infection mostly through fleas; about half of untreated cases are fatal.	Two words: Black Death (you know, the disease that wiped out up to two thirds of Europe during the Middle Ages).	Mishaps at various labs since 2003 include an infected monkey bite, missing plague-ridden mice and lost shipments of the bacteria.	A little. No one reported becoming ill, but the bacteria's long incubation period makes it easy to unwittingly transmit.
 ENCEPHALITIS	Russian spring-summer encephalitis is a tick-borne virus that can cause brain swelling. The mortality rate is 20 percent.	If the infection doesn't kill you, it could cause permanent neurological damage.	Jan. 2004: A worker at a CDC facility in Colorado discovers broken vials of the virus and cleans them up without wearing protective gear.	No. The facility has reported no illnesses, and the virus is typically spread by a species of tick found almost exclusively in the Far East.
 EBOLA	An untreatable virus native to Africa that causes fever, rash and bleeding, killing 65 percent of its victims.	Nature's ugliest terrorist. Ebola is hideously painful, extremely deadly and highly contagious.	Feb. 2004: In a lab in Ft. Detrick, Md., an infected mouse kicks over a syringe, scratching a worker's hand.	Not really. The virus is horrific, but it's relatively easy to contain and hard to weaponize. The worker was quickly quarantined and never fell ill.

FROM TOP: STEVE COLAGATTI/IMAGES; KEVIN WOODRUFF/ARND BRONKHORST/GETTY IMAGES; PHOTOFEST; SCOTT CAMAZINGI/PHOTO RESEARCHERS; CHARLES JAYNE/CORBIS

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WHAT'S THE BIG
IDEA?

THE UNITED MYSPACE PAGES OF AMERICA

The creators of *techpresident.com* on how the Internet is changing the presidential race and whether online popularity will ever translate to votes

DURING THE LAST presidential election, Andrew Rasiej was busy advising Howard Dean on his campaign's use of technology. Micah Sifry was a journalist covering the intersection of politics and the Internet for *The Nation*. This time around, the two are running the first-ever Web site that tracks how the candidates are using—and just as often, failing to use—technology to bolster their campaigns.

The site features interactive charts that monitor the popularity of candidates on social-networking sites like MySpace and Facebook and tallies how often their names are mentioned elsewhere online, while a bipartisan team of bloggers provides daily commentary. Rasiej and Sifry talked to us about how the Internet is changing politics and if Barack

Obama's 190,000 MySpace friends are really going to make a difference on Super Tuesday. —KALEE THOMPSON

Q: We heard a lot about how important the Web was in the 2004 election. How have things changed since then?

Rasiej: There are far more tools available now. The voters themselves are creating and distributing content. It's more than just blogging, which was the primary force in the Dean campaign.

Sifry: An ordinary person can be politically active and influential in more ways. "Friending" a candidate on MySpace or Facebook, for instance, can have as much meaning as sticking a bumper sticker on your car. But voters can go further. They can demand that their candidates come to their town using

Eventful, an online events planner. Or they can take a video camera out and capture a candidate in some real-live human interaction that sheds more light on whether that candidate is fit to be president. That's the kind of content that spreads, because it's interesting. And it makes this a very different election.

Q: Barack Obama and Ron Paul seem to be the most popular kids in cyberspace, though they're not the front-runners in the polls.

Rasiej: Being online doesn't guarantee being front-runner. But online enthusiasm for a particular candidate produces assets that can be used by campaigns for political purposes: The by-product of online action is money. The Obama and Paul campaigns have built

CONTINUED ON PAGE 351

COUCH SURFING Andrew Rasiej (left) and Micah Sifry commandeer their Web site, *techpresident.com*, from their comfy headquarters in New York.





A man and a woman are standing in the center of the frame, holding a large green sign. They are both smiling. The woman is wearing a blue top and a patterned skirt, and the man is wearing a light-colored shirt and trousers. In the background, a group of people are dancing under a gazebo at night. String lights are visible hanging from the gazebo and around the area.

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PRECAUTIONS

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As a predominantly renally excreted drug, patients with moderate to severe renal impairment (creatinine clearance of ≤ 50 mL/min) treated with SPRIVA should be monitored closely (see CLINICAL PHARMACOLOGY, Pharmacokinetics, Special Populations, Renally-impaired Patients).

Information for Patients

It is important for patients to understand how to correctly administer SPRIVA capsules using the HandiHaler inhalation device (see Patient's Instructions for Use). SPRIVA capsules should only be administered via the HandiHaler device and the HandiHaler device should not be used for administering other medications.

Capsules should always be stored in sealed blisters. Remove only one capsule immediately before use, or its effectiveness may be reduced. Additional capsules that are exposed to air (i.e., not intended for immediate use) should be discarded.

Eye pain, discomfort, blurred vision, visual halo or colored images in association with red glistening conjunctival congestion and corneal edema may be signs of acute narrow-angle glaucoma. Should any of these signs and symptoms develop, consult a physician immediately. Miotic eye drops alone are not considered to be effective treatment.

Care must be taken not to allow the powder to enter into the eyes as this may cause blurring of vision and pupil dilation.

SPRIVA HandiHaler is a once-daily maintenance bronchodilator and should not be used for immediate relief of breathing problems, i.e., as a rescue medication.

Drug Interactions

SPRIVA has been used concomitantly with other drugs commonly used in COPD without increases in adverse drug reactions. These include sympathomimetic bronchodilators, methylxanthines, and oral and inhaled steroids. However, the co-administration of SPRIVA with other anticholinergic-containing drugs (e.g., ipratropium) has not been studied and is therefore not recommended.

Drug/Laboratory Test Interactions

None known.

Contraindications, Mutagenesis, Impairment of Fertility

No evidence of tumorigenicity was observed in a 104-week inhalation study in rats at tiotropium doses up to 0.059 mg/kg/day, in an 83-week inhalation study in female mice at doses up to 0.145 mg/kg/day, and in a 101-week inhalation study in male mice at doses up to 0.145 mg/kg/day. These doses correspond to 25, 35, and 35 times the Recommended Human Daily Dose (RHDD) on a mg/m² basis, respectively. These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies.

Tiotropium bromide demonstrated no evidence of mutagenicity or clastogenicity in the following assays: the bacterial gene mutation assay, the V79 Chinese hamster cell mutagenesis assay, the chromosomal aberration assays in human lymphocytes *in vitro* and mouse micronucleus formation *in vivo*, and the unscheduled DNA synthesis in primary rat hepatocytes *in vitro* assay.

In rats, decreases in the number of corpora lutea and the percentage of luteal phase were noted at inhalation tiotropium doses of 0.078 mg/kg/day or greater (approximately 35 times the RHDD on a mg/m² basis). No such effects were observed at 0.009 mg/kg/day (approximately 4 times the RHDD on a mg/m² basis). The fertility index, however, was not affected at inhalation tiotropium doses of 0.009 mg/kg/day (approximately 4 times the RHDD on a mg/m² basis). These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies.

Pregnancy

Pregnancy Category C

No evidence of structural alterations was observed in rats and rabbits at inhalation tiotropium doses of up to 1.471 and 0.007 mg/kg/day, respectively. These doses correspond to approximately 64 and 0.007 times the recommended human daily dose on a mg/m² basis. However, in rats, fetal resorption, litter loss, decreases in the number of live pups at birth and the mean pup weights, and a delay in pup sexual maturation were observed at inhalation tiotropium doses of 0.078 mg/kg/day (approximately 35 times the RHDD on a mg/m² basis). In rabbits, an increase in post-implantation loss was observed at an inhalation dose of 0.4 mg/kg/day (approximately 360 times the RHDD on a mg/m² basis). Such effects were not observed at inhalation doses of 0.009 and up to 0.088 mg/kg/day in rats and rabbits, respectively. These doses correspond to approximately 4 and 10 times the RHDD on a mg/m² basis, respectively. These dose multiples may be over-estimated due to difficulties in measuring deposited doses in animal inhalation studies.

There are no adequate and well-controlled studies in pregnant women. SPRIVA should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Use in Labor and Delivery

The safety and effectiveness of SPRIVA has not been studied during labor and delivery.

Nursing Mothers

Clinical data from nursing women exposed to tiotropium are not available. Based on lactating rodent studies, tiotropium is excreted into breast milk. It is not known whether tiotropium is excreted in human milk, but because many drugs are excreted in human milk and given these findings in rats, caution should be exercised if SPRIVA is administered to a nursing woman.

Pediatric Use

SPRIVA HandiHaler is approved for use in the maintenance treatment of bronchospasm associated with chronic obstructive pulmonary disease, including chronic bronchitis and emphysema. This disease does not normally occur in children. The safety and effectiveness of SPRIVA in pediatric patients have not been established.

Geriatric Use

Of the total number of patients who received SPRIVA in the 1-year clinical trials, 426 were <65 years, 375 were 65–74 years and 105 were ≥75 years of age. Within each age subgroup, there were no differences between the proportion of patients with adverse events in the SPRIVA and

the comparator groups for most events. Dry mouth increased with age in the SPRIVA group (differences from placebo were 9.0%, 17.1%, and 16.2% in the aforementioned age subgroups). A higher frequency of constipation and urinary tract infections with increasing age was observed in the SPRIVA group in the placebo-controlled studies. The differences from placebo for constipation were 0%, 1.8%, and 7.8% for each of the age groups. The differences from placebo for urinary tract infections were –0.5%, 4.6% and 4.5%. No overall differences in effectiveness were observed among these groups. Based on available data, no adjustment of SPRIVA dosage in geriatric patients is warranted.

ADVERSE REACTIONS

Of the 2,663 patients in the four 1-year and two 6-month controlled clinical trials, 1,306 were treated with SPRIVA (tiotropium bromide inhalation powder) at the recommended dose of 18 mcg once a day. Patients with narrow angle glaucoma, or symptomatic prostatic hypertrophy or bladder outlet obstruction were excluded from these trials.

The most commonly reported adverse drug reaction was dry mouth. Dry mouth was usually mild and often resolved during continued treatment. Other reactions reported in individual patients and consistent with possible anticholinergic effects included constipation, increased heart rate, blurred vision, glaucoma, urinary difficulty, and urinary retention.

Four multicenter, 1-year, controlled studies evaluated SPRIVA in patients with COPD. Table 1 shows all adverse events that occurred with a frequency of ≥3% in the SPRIVA group in the 1-year placebo-controlled trials where the rates in the SPRIVA group exceeded placebo by ≥1%. The frequency of corresponding events in the ipratropium-controlled trials is included for

Table 1. Adverse Experience Incidence (% Patients) in One-Year-COPD Clinical Trials

Body System (Event)	Placebo-Controlled Trials (n = 550)	SPRIVA-Controlled Trials (n = 371)	Ipratropium-Controlled Trials (n = 356)	Ipratropium-Controlled Trials (n = 175)
Body as a Whole				
Accidents	13	11	5	8
Chest Pain (non-specific)	7	5	5	2
Edema, Dependent	5	4	3	5
Gastrointestinal System Disorders				
Abdominal Pain	5	3	6	6
Constipation	4	2	1	1
Dry Mouth	16	3	12	6
Dyspepsia	6	5	1	1
Vomiting	4	2	1	2
Musculoskeletal System				
Myalgia	4	3	4	3
Resistance Mechanism Disorders				
Infection	4	3	1	3
Moniliasis	4	2	3	2
Respiratory System (upper)				
Epistaxis	4	2	1	1
Pharyngitis	9	7	7	3
Rhinitis	6	5	3	2
Sinusitis	11	9	4	3
Upper Respiratory Tract Infection	11	37	43	35
Skin and Appendage Disorders				
Rash	4	2	2	2
Urinary System				
Urinary Tract Infection	7	5	4	2

Arthritis, coughing, and influenza-like symptoms occurred at a rate of 3.3% in the SPRIVA treatment group, but were <1% in excess of the placebo group.

Other events that occurred in the SPRIVA group at a frequency of 1–3% in the placebo-controlled trials where the rates exceeded that in the placebo group include: Body as a Whole: allergic reaction, leg pain; Central and Peripheral Nervous System: dysphasia, paresthesia; Gastrointestinal System Disorders: gastrointestinal disorder not otherwise specified (NOS), gastroesophageal reflux, stomatitis (including ulcerative stomatitis); Metabolic and Nutritional Disorders: hypercholesterolemia, hyperglycemia; Musculoskeletal System Disorders: skeletal pain; Cardiac Events: angina pectoris (including aggravated angina pectoris); Psychiatric Disorders: depression, infections; herpes zoster; Respiratory System Disorder (Upper): laryngitis; Vision Disorders: cataract. In addition, the adverse events observed in the clinical trials with an incidence of <1% were atrial fibrillation, supraventricular tachycardia, angioedema, and urinary retention.

In the 1-year trials, the incidence of dry mouth, constipation, and urinary tract infection increased with age (see PRECAUTIONS, Geriatric Use).

Two multicenter, 6-month, controlled studies evaluated SPRIVA in patients with COPD. The adverse events and the incidence rates were similar to those seen in the 1-year controlled trials. The following adverse reactions have been identified during worldwide post-approval use of SPRIVA capsules, dysphagia, epistaxis, hoarseness, intestinal obstruction including ileus, paralytic, intraocular pressure increased, oral candidiasis, palpitations, pruritus, tachycardia, throat irritation, and urticaria.

DOSEAGE AND ADMINISTRATION

The recommended dosage of SPRIVA HandiHaler (tiotropium bromide inhalation powder) is the inhalation of the contents of one SPRIVA capsule, once-daily, with the HandiHaler inhalation device (see Patient's Instructions for Use).

No dosage adjustment is required for geriatric, hepatically-impaired, or renally-impaired patients. However, patients with moderate to severe renal impairment given SPRIVA should be monitored closely (see CLINICAL PHARMACOLOGY, Pharmacokinetics, Special Populations and Contraindications).

SPRIVA capsules are for inhalation only and must not be swallowed.

HOW SUPPLIED

The following packages are available:

- carton containing 5 SPRIVA capsules (1 unit-dose blister card) and HandiHaler inhalation device (NDC 0597 0075-4)
- carton containing 30 SPRIVA capsules (3 unit-dose blister cards) and 1 HandiHaler inhalation device (NDC 0597 0075-4)
- carton containing 90 SPRIVA capsules (9 unit-dose blister cards) and 1 HandiHaler inhalation device (NDC 0597 0075-4)

SV-B5 (10-06)

65626/US/1

Rx only



SPU00046

SV44080

(CONTINUED FROM PAGE 32)

robust online communities, and they're mining them [for money]. It remains to be seen to what degree they can be mined to create actual votes at the polls.

Sifry: I'd also say that the fact that they have this very wide and diverse base online will enable them to stay in the race longer than they otherwise might have. Ron Paul clearly has demonstrated that online enthusiasm can be converted into real support, whether it's money or boots on the ground. He's probably not going to be president, or even the Republican nominee. But my guess is, he's going to last a lot longer in the Republican primary than most of the other candidates because of this base.

Q: I noticed that the Democrats seem to have more online activity.

Sifry: We've been watching this since last January, and in terms of just organic mentions of the candidates on

"THE ISSUE IS WHETHER THE POLITICAL PARTIES VIEW THE INTERNET AS FRIEND OR FOE."

blogs, the Democrats outnumber the Republicans by about two to one. You see a similar thing reflected in the number of donations and the amount of donations.

Q: Why is that?

Rasiej: The issue is whether the parties view the Web as friend or foe. The reason the Republicans are having a significantly harder time is that this bottom-up, Internet-style campaign culture that's coming to the fore is very foreign to traditional Republican political messaging and distribution. On the other hand, the Democrats' information

infrastructure was pretty lame compared with the Republicans'. But as the tools of the Internet became easier to use, the Democrats' rank and file took hold of the technology.

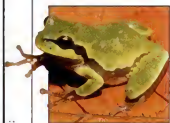
Q: So what's next?

Rasiej: We're looking at tracking the actual media coverage the candidates get and which quotes by the candidates are getting the most exposure in the press. We are also considering launching a new site, TechCongress, to keep track of how technology is being used in [this year's] Congressional races.

THE EQUATION

A BIG LEAP FOR ANTIBIOTICS

New medicine inspired by frog skin could put an end to drug-resistant bacteria



FROG



KNIFE



NEW ANTIBIOTIC

FORGET WITCHES' BREW and warts. Clammy frog skin is fast earning a new reputation—as a miracle drug. University of Pennsylvania scientists have developed a potent compound that mimics molecules in frog skin that stab bacteria to death. "The compound has yet to meet a bug it can't kill," says Nick Landekic, CEO of PolyMedix, the Radnor, Pennsylvania-based company spun off from the Penn research.

The medicine, set to enter clinical trials in April, is sorely needed. Bacteria are quickly developing resistance to even the toughest antibiotics. A recent study by the Centers for Disease Control and Prevention found that a lethal strain of drug-resistant staph, a com-

mon bacterial infection in hospitals, caused nearly 19,000 deaths in 2005 in the U.S., eclipsing the annual U.S. death toll of HIV/AIDS.

Antibiotics work by crippling key proteins inside bacteria. But the bug often outsmarts the drugs by modifying receptor sites on the proteins, which prevents antibiotics from taking hold. The amphibian-inspired approach overcomes this survival technique by poking thousands of tiny holes in the bacterium's membrane, killing the microbe outright. Countering this attack would require the bacteria to fully restructure its membrane. "The possibility of bacteria developing resistance to this class of drugs," Landekic says, "would be like people developing bulletproof skin." —MICHELLE BRYNER

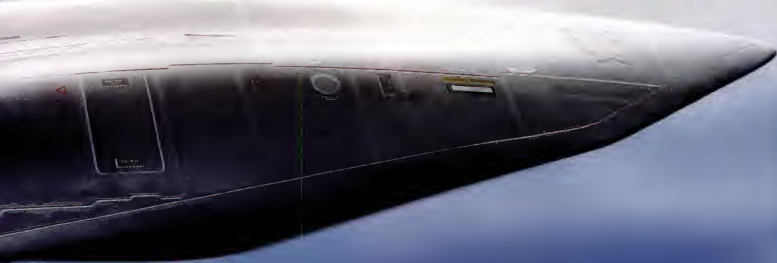
FUTURE TECH: SCRAMJETS

THE HYPER



SONIC

AGE IS NEAR



Engineers have tried for decades to build fully functional scramjets—hypersonic jet engines that could carry aircraft from New York to Tokyo in two hours. Now new research and big breakthroughs mean success is finally within sight

BY MICHAEL BELFIORE ILLUSTRATION BY NICK KALOTERAKIS

▲ **SILVER BULLET** If it works, the HTV-3X will be the first reusable scramjet-powered plane. It will be able to take off from a runway, fly at speeds of up to Mach 6, land safely, and then do it again.

THREE KEY FACTS

- 1** A scramjet mixes fuel with highly compressed air drawn from the atmosphere for rocket-like power in a much lighter craft.
- 2** In order to work, a scramjet must first be propelled to Mach 5 or faster by a rocket or a ramjet, a sub-hypersonic air-breathing jet engine.
- 3** In 2004, NASA's X-43A scramjet hit Mach 9.6, setting the record for fastest jet flight. After a rocket boost, the scramjet reached top speed in only 10 seconds.

LAST MARCH, engineers from Pratt & Whitney Rocketdyne (PWR) gathered in the control room of a high-temperature tunnel at NASA's Langley Research Center in Virginia. After a countdown, a jet of blue flame fueled by methane gas roared down the 12-foot length of the tunnel. A low rumble crept into the control room. It sounded like a rocket firing, which actually wasn't far from the truth.

"Okay to inject," a test director announced when the flame had reached full force. An angular pedestal covered in bolted copper plates rose from the floor of the chamber, placing an experimental scramjet engine called the X-1 into the inferno. "AOA modulating," called the test director as the engine tilted slightly. "Model on centerline." Then, "We are in ignition." And with that, an exhaust flame even hotter than the 2,000°F-plus methane jet around it began to dance behind the activated engine, growing brighter as it ramped up to full thrust. After one minute, the engine shut down and descended through the floor.

The test was part of the X-51A Flight Test Program, a research project funded by the Air Force Research Laboratory and the Defense Advanced Research Projects Agency (Darpa), the Pentagon's research arm. The X-51A project is, in turn, one piece of a global effort—part collaboration, part race—to build jet-powered aircraft that fly as fast as rocket ships. And the technology that will make this breakthrough possible is the scramjet, an engine that inhales air at tremendous speeds, squeezes the air until it's thousands of degrees hot, and then mixes that air with fuel to generate massive thrust at higher speeds than any other jet-engine design.

The X-1 scramjet engine, which will eventually power the X-51A aircraft, is the most advanced scramjet engine ever built. The blowtorch blasting through the chamber was meant to simulate the extreme heat generated by flying faster than Mach 6. In all, the team at Langley would repeat this test 44 times.

"We tested it at Mach 4.6, 5.0 and 6.5," says Curtis Berger, the X-51A program manager at PWR. "The amount of time that this thing was actually running and creating thrust was just about 17.8 minutes." He pauses to let that sink in. "Over 17 minutes of time on this engine. That's a lot of time for a scramjet engine."

To put things in context, the world's fastest jet, the Air Force's SR-71 Blackbird spy plane, set a speed record of Mach 3.3 in 1990 when it flew from Los Angeles to Washington, D.C., in just over an hour. That's about the limit for jet engines; the fastest fighter planes barely crack Mach 1.6. Scramjets, on the other hand, can theoretically fly as fast as Mach 15—nearly 10,000 mph.

This could mean two-hour flights from New York to Sydney. It could also mean missiles capable of hitting targets on another continent at a moment's notice, and when you put it that way, it's not surprising that militaries around the world—the U.S., Australia, China and perhaps others—are trying to build them. After decades on the drawing board, it seems scramjet technology is finally about to arrive.

A MATCH IN A HURRICANE

Ordinary jets have a major limitation: They can't go faster than Mach 3 without their turbine blades melting. Rocket ships can reach Mach 25, but they have to carry tremendous amounts of liquid oxygen to burn their fuel. The space shuttle, for example, weighs only 165,000 pounds empty, but it must carry 226,000 pounds of liquid hydrogen and 1.4 million

HOW TO GO REALLY, really fast isn't the only problem facing the designers of hypersonic vehicles. Thermal management—that is, making sure your aircraft doesn't melt while doing Mach 10—is a huge challenge, and one that will drive the design of any scramjet-powered craft. Here are a few of the ways engineers hope to solve that and other problems.

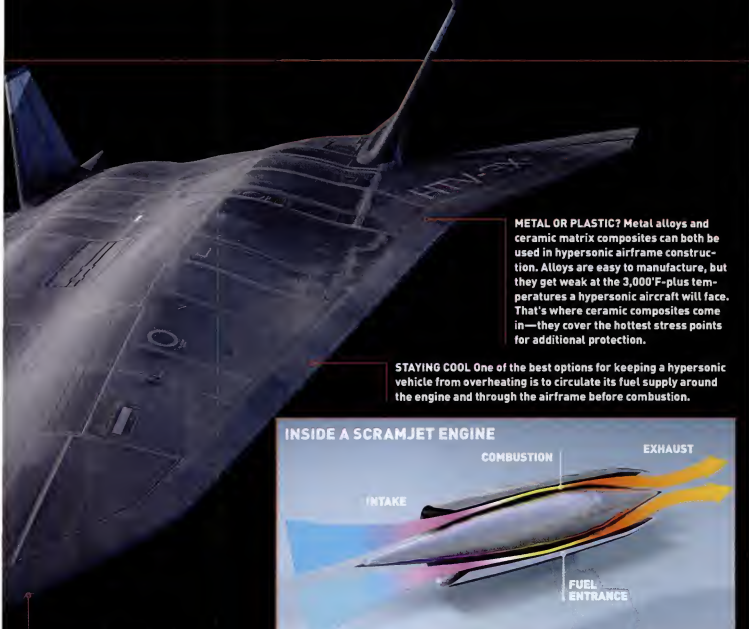
pounds of liquid oxygen to reach orbit.

An air-breathing jet engine with no moving, meltable parts, such as a scramjet, can solve these problems. A scramjet is an advanced form of a "ramjet," an engine that takes the air rushing into the engine and "rams" it into the combustion chamber, creating intense pressures that can sustain combustion at the furious rate that Mach-3-plus speeds demand. But ramjets have limits too. The air entering the engine has to be slowed to subsonic speeds for it to run efficiently. And that air is so hot that no matter what measures are taken to cool it, a ramjet-powered craft must stay under Mach 5 to keep from disintegrating.



KIRS HOLLAND

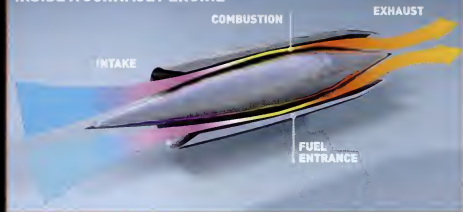
**THE SR-71 MADE HISTORY AT MACH 3.3.
A SCRAMJET COULD REACH MACH 15.**



METAL OR PLASTIC? Metal alloys and ceramic matrix composites can both be used in hypersonic airframe construction. Alloys are easy to manufacture, but they get weak at the 3,000°F-plus temperatures a hypersonic aircraft will face. That's where ceramic composites come in—they cover the hottest stress points for additional protection.

STAYING COOL One of the best options for keeping a hypersonic vehicle from overheating is to circulate its fuel supply around the engine and through the airframe before combustion.

INSIDE A SCRAMJET ENGINE



KNIFE EDGE Leading edges must be sharp for aerodynamic efficiency. Make them too sharp, though, and they can't radiate heat quickly enough.

▲ A scramjet engine stays lit at hypersonic speeds by using that speed to compress its fuel-air mixture. Air rushing in gets squeezed down as the intake narrows to a thin tunnel; it gets so hot that the fuel ignites in the combustion chamber, producing thrust.

But a scramjet—a “supersonic combustion ramjet”—changes things. A scramjet does away with the diffuser that a ramjet uses to slow down incoming air, allowing the air to move through the engine at supersonic speeds so it can fly above Mach 5. The tradeoff: A scramjet engine in flight is a delicate system. Achieving balanced combustion at those speeds is an engineering challenge often compared to keeping a match lit in a hurricane.

So far, the most public scramjet project has been the National Aerospace Plane, or NASP. Unfortunately, it was a spectacular failure. Announcing the project in his 1986 State of the Union

address, President Reagan called it “a new Orient Express” that would be able to reach Tokyo from Dulles Airport in two hours; the goal was to have it running by the late 1990s. NASP was meant to be all things to all customers—America’s next space shuttle as well as the Air Force’s next bomber and the next big thing in passenger travel. But by 1994, it appeared that research had stalled, and President Clinton canceled NASP. That might have been a good thing. “We didn’t stop our research,” says Charlie Brink, a scramjet program manager at the Propulsion Directorate at the Air Force Research Laboratory. “We reevaluated it and said: Now that

we’re not trying to make a Mach 6-to-25 vehicle take off from a runway, let’s take the technical problem and break it down into more manageable chunks.”

“What you’re seeing now is a transition of the technology out of the laboratories into the flight-test domain,” says David Van Wie, a scramjet research scientist at the Johns Hopkins University Applied Physics Laboratory. Armed with a new understanding of hypersonic aerodynamics and air-breathing propulsion, Van Wie says, “it’s really to the point that people who work in the field feel they’re ready to take the steps into flight test, experimentation and demonstration.”

ESCAPE FROM THE LAB

In 2002, Australian researchers with the HyShot program at the University of Queensland's Centre for Hypersonics made history by conducting the world's first scramjet "flight." They strapped a small scramjet engine into the nose cone of a solid-fuel rocket and launched it to the edge of space. Then, some 200 miles up, the rocket dropped off, the scramjet shed its protective fairing and, as planned, nosed over and plummeted back toward Earth at thousands of miles an hour. At an altitude of 20 miles, the scramjet engine kicked in, firing for five seconds and reaching Mach 7.6, or more than 5,000 mph, before slamming into the ground. It wasn't graceful, but it was a historic achievement and a scientific success—a low-cost way to gather data from a scramjet while subjecting it to brutal heat and incredible velocity outside of a wind tunnel.

Since then, a loose federation of researchers from NASA, the Air Force, the Navy, Darpa and the University of Queensland, working on a variety of projects, has conducted a number of tests outside the lab. So far, no engine has pulled off more than a few seconds of sustained flight. But there have been major breakthroughs along the way. In 2004, NASA's unmanned X-43A—a disposable, rocket-boosted craft that was launched from a moving airplane—reached Mach 9.6, setting the world speed record for a jet-powered aircraft. It took only 10 seconds of scramjet power to get it up to that speed. And HyCause, the program that succeeded HyShot, conducted tests in Australia last summer that reached Mach 10, but only for three seconds.

A scramjet that can stay lit for several minutes could power a hypersonic long-range missile. That, at least, is the idea behind a joint Darpa and Navy project called Hypersonics Flight Demonstration, or HyFly. Last fall, the program carried out the latest in a series of test flights in which a scramjet was



TORTURE CHAMBER The X-1 scramjet engine is subjected to the hellfire of a test tunnel at NASA's Langley Research Center to simulate the intense heat and friction of hypersonic flight.

dropped from an F-15 fighter jet off Point Mugu in California and boosted to operating speed by rocket. The goal was to reach Mach 6 and keep the scramjet going for 100 seconds or more. (It didn't make it that time, but the tests will continue, program officials say.)

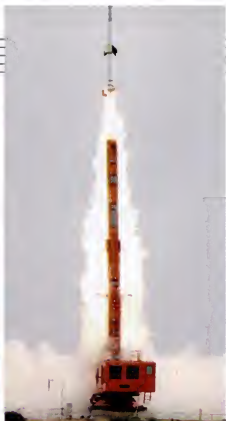
A payload-carrying, piloted craft that can take off and land under its own power will need an engine that can produce power for a lot longer than 100 seconds, though. Breaking that barrier is the goal of the X-51A Flight Test Program, whose engineers spent much of last year torching its X-1 engine design in Langley's high-temperature test tunnel. So far, the X-1 has had to take more punishment than any scramjet engine ever built. It's made of a steel-nickel alloy that stays strong up to 2,100°F, and its leading edges are coated in a heat-resistant carbon mesh. Even these materials aren't enough, though, so the X-1's engineers borrowed a technique from rocket designers, who typically circulate fuel—in this case, the same petroleum-based jet fuel that powered the SR-71—along channels within the engine's walls before it enters the combustor. This both cools the 3,000°F-plus

combustor and preconditions the fuel, turning it into a hot gas that packs 10 percent more energy than it does in liquid form.

The X-51A's target is five minutes of uninterrupted scramjet-powered flight. If it works, longer-burning scramjets should quickly follow. "The five minutes of flight we're talking about is not limited by the propulsion system," Berger says. "That's just how much gas we have in the tank." On a modified vehicle with a bigger gas tank, that five minutes could easily turn into an hour or longer. And that, says Mike McKeon, PWR's manager of Hypersonic and Advanced Programs, is key. "This engine has demonstrated that the propulsion technology is ready for application," he says of the X-1. "It's no longer in the research-technology mode." Next-generation engines based on the X-1 are already being built at PWR's plant in Florida.

With any luck, sometime in 2009, the X-51A will shatter all previous records for sustained scramjet ignition. The PWR team imagines that a B-52 bomber will take off from Edwards Air Force Base in California's Mojave Desert, head toward the coast and, at 45,000 feet, drop the X-51A from the plane. A solid-fuel rocket attached to the X-51A will fire, blasting it up to 60,000 feet and past Mach 4.5, and then drop off to let

THE X-43A HIT MACH 9.6 SECONDS AFTER ITS SCRAMJET KICKED IN.



FIELD TESTING Clockwise from top left: The record-setting scramjet-powered X-43A; a HyCause rocket with a scramjet engine on its nose takes off; HyShot's scramjet engine.

the scramjet ignite. For five minutes, the scramjet will accelerate the X-51A to a peak speed past Mach 6 and an altitude above 80,000 feet. Then it will fly into the Pacific, its data safely telemetered to engineers on the ground.

The test will also mark the moment when scramjets move from flash-in-the-pan science experiments to useful tools. "This is an airplane," Berger emphasizes, "not just something where you light a scramjet and fire it and see where it goes. This is really beyond something you might do for a weapon application. The whole idea is to prove the practicality of a free-flying, scalable, scramjet-powered vehicle."

THE REAL RACE BEGINS

The first true reusable, free-flying scramjet could be Darpa's HTV-3X. Also known as Blackswift, the unmanned vehicle looks like an alien spaceship, with black curves, a rapier-like prow and oval exhaust ports. It's still only in the planning stages as part of Darpa's Falcon program, but it could represent the biggest breakthrough in aeronautics since the jet engine itself. It will demonstrate for the first time all the technologies needed for a practical scramjet-powered aircraft by taking off and landing under its own power and running on scramjets as long as needed

to complete its mission.

The HTV-3X could make its inaugural flight as early as 2012. Here's how a perfect mission would go: The unmanned craft taxis out of a hangar at Edwards Air Force Base. Its twin conventional turbine engines throttle up before it accelerates down the runway and climbs into the desert sky, followed closely by a chase plane. The chase plane keeps pace until shortly after the unmanned craft hits the speed of sound. At Mach 2, doors just within the jets' inlets close off the turbines and open the airflow to the scramjet engines, which fire out of the same nozzles used by the turbine jets. On the ground, engineers watch their bird hit Mach 6, twice as fast as any turbine-jet-powered jet ever built. The test completed, the craft slows to subsonic speed, switches to turbine jets, and lands back at Edwards, mission accomplished.

Darpa officials are keeping quiet about Blackswift for now. Spokesperson Jan Walker says no project engineers could give interviews for this article because "it's a very busy time for the program." But Pratt & Whitney Rocketdyne is already at work on the engine that HTV-3X will use—a combined-cycle turbine-scramjet engine—and although Lockheed Martin won't confirm it, the company's famously secretive Skunk

Works division is widely believed to be building the vehicle itself.

Meanwhile, there's competition. Last July, engineers from China showed up at the American Institute of Aeronautics and Astronautics Joint Propulsion Conference in Cincinnati and revealed a growing scramjet research program of their own, including a new hypersonic wind tunnel in Beijing and work on rocket-powered combined-cycle scramjets. None of the American scramjet experts we talked to would discuss their reactions to the Chinese revelations. But Craig Covault, an editor at *Aviation Week & Space Technology* who reported on the conference, believes one of the main reasons the Chinese attended was to glean all available intel on Western scramjet research. "I would bet that they have a serious research program under way that has a lot more going on than just the few papers that they issued at this forum," Covault says. "The reason that they issued them was just kind of a message to the rest of the world that they are engaged in these high-tech things. It also allowed them to get the 500 or more other papers in propulsion technology of all kinds delivered at the conference."

Scramjet projects have failed before, and some of the initiatives under way today could fail too. But many researchers say that this time around, scramjets are for real. "Advanced propulsion technology has a development timescale that appears to be on the order of decades," says Johns Hopkins's Van Wie. "The first scientific paper on rockets was published in 1903, and rockets became practical during World War II, 40-some years later." He points to a seminal conference in 1960 during which researchers first hashed out the major challenges to building practical scramjets. "So if you look at that—1960 to now, 47 years or so—it's kind of on the same timescale to see this roll out." In other words, that two-hour flight to Tokyo just might be leaving sooner than you think.

Michael Belfiore's book Rocketeers chronicles the private space industry.



YOUR GUIDE TO THE YE



ATTACK OF THE JELLIES

A spate of jellyfish invasions is imperiling crucial fishing grounds, menacing beachgoers, and

IT'S LIKE A SCENE from a bad '50s monster flick: Nation attacked by swarms of poisonous giant jellyfish! But that's exactly what's happening off the Japanese coast. The dishwasher-size Nomura's jellyfish, a gelatinous 400-pound blob with thousands of stinging tentacles, was once uncommon in Japanese waters. By early 2006, its numbers were estimated to be in the millions.

Elsewhere in the world, similar stories played out. In July, a creature called *Mnemiopsis* inundated Swedish seas; the invasive species is believed to have hitchhiked into the northern Atlantic by shipping vessel. And in September, millions of purple jellies called *Pelagia noctiluca*

swarmed the Italian coast. The out-of-season visitors interrupted fishing operations and scared away beachgoers with their vicious stings.

From Tasmania to Namibia to the Gulf of Mexico, recent jellyfish invasions have puzzled scientists and devastated local economies. Closed beaches are the least of the problem. Jellies have stung farmed salmon, clogged nets on fishing vessels, even blocked water-intake valves at nuclear power plants.

"The number of occurrences, their duration and geographical extent—all of those are exceptional," says University of Connecticut zoologist Ann Bucklin, who is heading up the

count of zooplankton—marine animals that drift with currents—for the Census of Marine Life, an international effort to count all ocean animal species by 2010 (jellyfish are one type of zooplankton). "It appears to be outside the normal variation that we've seen in the past," she adds. "The [zooplankton] blooms seem to be dramatically more severe than they used to be."

Of all ocean species, jellyfish are among the least studied by scientists, in part because of their lack of obvious utility to humans, and in part because of the specific challenges of working with them. The invertebrates are difficult to handle, often poisonous, and prone to

THE YEAR AHEAD

JANUARY: Smart USA will sell models in the U.S. for the first time. Consumers will be able to choose among a convertible and two coupes, starting at \$11,590. More than 30,000 Americans have paid to reserve one of the pint-size vehicles.



JANUARY: Washington State will implement a voluntary program to implant radio-frequency ID (RFID) chips in driver's licenses to speed border crossings. Border agents will electronically retrieve identification and citizenship information from people as they drive up to crossings between Washington and Canada.



CLOCKWISE FROM TOP LEFT: COURTESY SMART USA; COURTESY EMOTIV SYSTEMS; ADRIAN BRADSHAW/COMBOS; COURTESY DYNAMIC; COURTESY SMART USA.



BACK TO THE FUTURE

IN 1998, a group of scientists from the U.S. Department of Energy's Pacific Northwest National Laboratory published a list of 10 environmental-technology breakthroughs expected by 2008. Here's how a few of them panned out.

THE PREDICTION: Genetically modified crops will be widespread.

THE OUTCOME: Most corn, soybean and cotton crops in the U.S. are genetically modified to resist pests or tolerate herbicides. But genetic modification is a controversial topic in many countries and is not in wide use throughout the rest of the world.

THE PREDICTION: We'll live in a paperless society.

THE OUTCOME: Sure, we have e-books and e-readers, but paper still rules cubicle-land. According to paper industry analyst RISI, U.S. consumption of paper products in the office peaked at 14.7 million tons in 1999 and declined to 12.7 million tons in 2006.

THE PREDICTION: Cars will get at least 80 miles per gallon.

THE OUTCOME: SUVs still rule the road, so average fuel economy this year will remain at a little more than 20 miles per gallon. But things may soon change, as 15 states have adopted or are considering emission regulations that will require a 30 percent reduction in greenhouse-gas emissions from new vehicles by 2016.

THE PREDICTION: The world will be filled with "green" products.

WHAT REALLY HAPPENED: There are many green products available, and Americans now recycle 32 percent of their waste. This is double the amount recycled during the early 1990s.

—MELINDA WENNER

AR IN SCIENCE



threatening coastal economies. Experts want to know why

disintegrating when caught in nets. Our limited knowledge of normal jelly habits makes it tough for scientists to pinpoint what's behind the mysterious trend.

What they do know is that jellies are opportunistic animals that capitalize quickly on changing conditions. "The more food you give them, the more jellyfish you get," says marine biologist Jennifer Purcell, who has studied the connection between changing environmental conditions and jellyfish density. Warmer ocean temperatures, increased ocean acidity, agri-

cultural pollution, and especially a decline in predators as the result of overfishing are all possible explanations for the recent jellyfish boom—and reasons why we're likely to see even more outbreaks this year and in the years to come.

Of course, some people are looking for ways to benefit. Japanese chefs have begun using jellyfish in more dishes and even cocktails, and researchers have harvested the animals' mucus for use in cosmetics. Call it the economy of a more gelatinous world. —KALEE THOMPSON



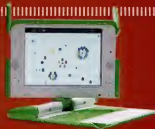
WINTER: The DeLorean returns.

Former DeLorean mechanic and restorer Stephen Wynne plans to sell two of the gull-wing cars a month, each made of approximately 90 percent original unused parts. A newly constructed DeLorean will start at \$57,500.



WINTER: The One Laptop Per Child project will be distributing laptops to children in South America, Southeast Asia and Africa.

The "green" machines cost around \$200 each and can be recharged with an AC adapter, solar power, a handcrank, a pull-cord and a foot pedal.



WORD WATCH

It's obscure geek speak now, but by 2009, even your mom will be fluent. —K.T.

ANTHROPOCENE (N.)

The most recent epoch in Earth's history, during which humans first began to affect the planet's climate and ecology. Approximately 1800 through the present.

BLOGICAL (ADJ.)

Illogical ramblings found online. See also, *blogic* (n.).

CARBON JUSTICE (N.)

The fair distribution of responsibility for addressing climate change, used in reference to the idea that countries should be required to curb CO₂ emissions in proportion to their population and per-capita CO₂ output. Additionally, a country's ability to pay would determine their overall responsibility.

CLOUD COMPUTING (N.)

Large-scale distributed computing services available over the Internet. The clusters (or "clouds") of computers give individual institutions or businesses ultrafast computing power without the high-maintenance server rooms.

ECOSYSTEM SERVICES (N.)

The value a healthy ecosystem offers humans or a local economy (calculated in dollars), providing an economic incentive to protect fragile habitats. For example, an insect called a lacewing furnishes a crucial ecosystem service in the U.S., eating corn earworms, aphids and other pests. Farmers who protect lacewing habitats will save money by cutting back on using conventional pesticides.

EXERGAMING (N.)

The action of playing videogames that do double duty as exercise regimens.

THE DARK SIDE OF THE OLYMPICS

WHO SAID ANYTHING ABOUT SPORTS? China has been using this summer's Games to flamboyantly tout its scientific and technological prowess. But with many foreign journalists in China complaining that they don't have the complete freedom to write independent stories, how much of what you read can be trusted? —M.W.

WHAT YOU'LL HEAR

Beijing's air has among the world's highest levels of nitrogen dioxide, but China will try to clear it by shutting down factories and taking a million cars off the streets.

Last July, after adopting more-stringent water-quality standards, the local authorities announced that Beijing's formerly nonpotable tap water is now safe to drink.

Beijing is cracking down on doping by doubling the number of drug tests it will administer to its athletes (compared with 2004).

China guarantees rain-free opening ceremonies. It plans to "seed" the clouds before the games with silver iodide.

Beijing is building a plethora of new stadiums and subways as part of a complete Olympic renovation.

China plans to shut down 4,000 of its unsafe (and highly polluting) coal mines.

WHAT YOU WON'T HEAR

Up to 70 percent of Beijing's summer particulate pollution originates outside the city, so it won't do much good to shut down the city itself.

Sure, the water is safe if you're standing right next to the treatment plant, but those same authorities admit that city pipes often contaminate the water.

Despite a lot of noise about stricter testing policy, China has a reputation for doping. Before the 2000 Sydney Olympics, 27 athletes withdrew from the games after some had suspicious test results.

Nobody knows if cloud seeding actually works. In 2003, the U.S. National Academy of Sciences called the science behind it too weak to confirm.

By one count, the construction boom will have forced 1.5 million Chinese out of their homes, and it's further polluting the air by releasing tons of dust.

China has tried this before without much success. It's next to impossible to monitor the area's many mines for compliance.



THE YEAR AHEAD

APRIL: India will launch *Chandrayaan-1*, its first unmanned spacecraft designed to orbit the moon. The orbiter will conduct research on the moon's makeup and create a 3-D atlas of its surface.

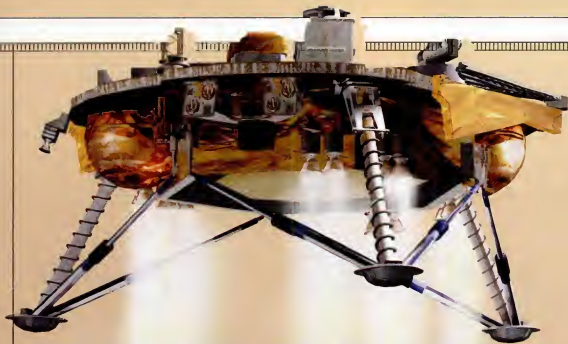


SPRING: The Web-ready airplane flies this year, as Alaska Airlines will start tests of satellite-linked onboard Wi-Fi. American Airlines and Virgin America will follow suit with a system of antennas that bounce signals to cellular phone towers on the ground.



PPX BET ON THE FUTURE
AT PPX.POPSCI.COM

PROPOSITION: Will China successfully suppress rainshowers for the Olympic opening ceremony?



OTHER WORLDS REVEALED

The innermost planet welcomes its first long-term visitor, a lander will scoop through the slush of Mars, and new Earths will emerge from distant space

THIS YEAR OF PLANETARY EXPLORATION

start hot. This month, after a 3.5-year journey, NASA's *Messenger* spacecraft will make the first of three flybys of Mercury, the closest planet to the sun and the least explored rocky planet in the solar system. After the third pass, *Messenger* will settle in orbit around the planet in 2011. The feat requires a huge amount of energy, careful trajectory planning, and strong radiation and temperature shielding. And once *Messenger* arrives, scientists will have much to explore. One critical puzzle: Why is diminutive Mercury made of the densest material in the solar system? The answer should shed light on how the rest of the solar system formed and evolved.

Speaking of "planet" and "evolved," another really big question about the solar system comes to mind—was there, or is there now, life on Mars? The *Phoenix* lander, set to touch down in the ice-rich Martian arctic this May, could provide clues. *Phoenix* will use its robotic arm to dig into the topsoil and ice and collect ground

samples. Scientists hope to learn about the planet's history and the potential for absence of Martian life. In the late 1970s, the two *Viking* landers failed to detect any signs of life on Mars. But when, a quarter century later, scientists used duplicates of the *Viking*'s detectors to search for life in the dry valleys of Antarctica and Chile's Atacama Desert—regions on Earth where we know life exists—the detectors failed to find it. Were the *Viking* landers blind to the presence of life on Mars? *Phoenix* could find out.

The search is also on for far-flung Earth-like planets. This year, scientists anticipate that the French space agency's *Corot* satellite—the first space telescope dedicated to planet-hunting—will turn up many of the 250 planets they're hoping to find, including dozens of Earth-like worlds. In addition, the Canary Islands' Gran Telescopio Canarias will begin studying the disks of dust swirling around distant stars for evidence of new planetary systems.

NOTABLES OF '08



Videogame Controller YOUR BRAIN

At least one tech company will release hardware that lets users control games with the aid of a headset that reads brain waves.

Biofuel MANURE

Forget corn. This year, new facilities in Iowa and California will begin producing energy from methane given off by livestock manure.

Threatened Animal THE POLAR BEAR

The U.S. Fish and Wildlife Service will decide this month whether to give polar bears protection under the Endangered Species Act. The U.S. Geological Survey recently announced that, with the continued melting of Arctic ice and loss of habitat, two thirds of the world's polar bears could be gone in 50 years. ▶



PPA BET ON THE FUTURE
AT PPA.POPSCI.COM

PROPOSITION: Will the *Phoenix* lander find verifiable signs of life on the surface of Mars by January 1, 2009?

SPRING: Microsoft will reach a milestone when the number of computers running Windows will reach one billion worldwide.



SUMMER: A European firm, Plastic Logic, will open the first factory in the world to mass-produce plastic digital displays, a key component of flexible e-book readers.



FUD Acronym for "fear, uncertainty and doubt," often used to describe the efforts of companies to disparage or undermine the soon-to-be-released products of competitors.

Investigating in person the nature of geographical hotspots identified through remote imaging. As in, "After we tentatively identified at least one new kind of Chinese nuclear submarine on Google Earth, we'd still require ground-truthing to confirm its capabilities."

Used to describe the increasingly blurry line between physics and mathematics. See also *physmatician*: "Brian Greene's book *The Elegant Universe* made him into the most famous physmatician since Stephen Hawking."

Electricity transferred wirelessly between electromagnetic coils resonating at the same frequency. Though not yet practical, the technology could someday eliminate that rats' nest of cords behind your desk.



GAMBLING ON A GOD PARTICLE

What will the world's largest collider really reveal? Physicists lay out the odds on their most likely—and unlikely—theories

WHEN IT COMES TO the Large Hadron Collider, the accelerator scheduled to start smashing protons this May, theorists agree on one thing: It will most likely produce the Higgs boson, the elusive "god particle" theorized to give everything in the universe mass.

Beyond that, they're taking bets. Fermilab collaborator Tommaso Dorigo of the University of Padua in Italy has bet \$1,000 that we'll find nothing beyond the Higgs, but he hopes he'll lose. We asked him and other physicists to give us the odds on their favorites.



Its existence would explain the origin of mass. Higgs bosons create a field through which all other particles must move. The Higgs field's resistance to this motion gives particles their mass.

that all particles in the universe come in matched pairs. Half are familiar—electrons, quarks and neutrinos—but their theoretical counterparts, called superpartners, are still undiscovered.

mass of a grain of salt, that evaporate almost instantaneously—too fast to consume any matter.

Some theorists speculate that many universes exist side by side with our own on a cosmic landscape, each with its own laws of physics and constants of nature.

If the fundamental vacuum state of the universe is not perfectly stable, the LHC could make it decay, taking everything in the cosmos with it.

-RENA MARIE PACELLA

Scientists know it's there; they just don't know what it is, and finding out is a task for the LHC. The substance makes up 80 percent of the matter in the universe but doesn't emit any light, so it's totally invisible.

Spatial dimensions beyond the known three of up-down, backward-forward and side-to-side could be diluting the force of gravity in our universe.

LHC collisions might produce harmless black holes, each a billion billionth the

Some physicists suspect

THE YEAR AHEAD

SUMMER: The Korea Superconducting Tokamak Advanced Research project will begin generating plasmas as hot as 18 million degrees Fahrenheit to produce **energy from fusion**. If KSTAR's tests are successful, it will provide valuable data to the International Thermonuclear Experimental Reactor (ITER), a multi-decade fusion-reactor project that will use the same technology.



• **JULY:** Regulations passed in 2006 will go into full effect, forcing New York City food vendors to eliminate artificial trans fats from their food. Banned ingredients will include margarine and partially hydrogenated vegetable oil.

[illegible]



CHECKERS IS SOLVED. NEXT?

THERE ARE 500 billion *billion* possible ways to arrange pieces on the board during a game of checkers. Still, after 18 years of research, Jonathan Schaeffer, a computer scientist at the University of Alberta in Canada, announced last year that his program had "solved" checkers—that is, it was unbeatable. How soon before we solve other popular games?

HEADS-UP TEXAS HOLD 'EM

TIME TO SOLVE: 5 years

Poker is generally no fun with just two people, but it's impossible to "solve" (in the scientific sense) with any combination of more than two players.

BACKGAMMON

TIME TO SOLVE: 10 years

The element of chance (rolls of the dice) makes the number of board combinations huge (10^{19}). Scientists know *how* to solve backgammon, but current computer technology can't do it.

CHESS

TIME TO SOLVE: 100 years

No one knows exactly how many possible board positions for chess exist, but it's thought to be somewhere between 10^{40} and 10^{48} . Schaeffer predicts that the game will not be solved in his lifetime.

GO

TIME TO SOLVE:

Anybody's guess

The extremely complicated game, which originated in ancient China, has far more board combinations than chess (10^{100}). Scientists have no idea how to solve it and won't even venture to guess when the technology will exist to definitively do so.

—KATE PICKERT



BREAKING THE LAW

IBM's 3-D chip stacks pack power into compact packages

FORTY YEARS AGO, engineer Gordon Moore famously predicted that the number of transistors that could fit on a silicon chip would double roughly every two years, making computers ever faster and more efficient. That truism will hit a brick wall in the next 15 years, as transistors approach the size of single atoms and manipulating them proves ever more difficult. This year, IBM will begin selling its work-around to the transistor-density problem, a vertically stackable chip that moves data 1,000 times as fast as what we use now.

If you open up your cellphone today, you'll probably find a pseudo-3-D chip inside—sticking ordinary chips on top of each other increases computing power without taking up too much space. It's the long wires that connect two chips around their outer edges that limit their ultimate processing speeds. Without better connections between the two chip layers, their utility is restricted to whatever can be

shunted through a few small wires.

IBM's solution is to make 3-D chips with vertical interconnections called through-silicon vias (TSVs). Instead of connecting the chips along the outer edges, TSVs tunnel down through the chip and connect to the next layer directly below it. The trick was in getting metal into the tiny holes that serve as the wires between the layers. Other companies aren't far behind. Samsung plans to use TSVs to make stacked DRAM chips and hopes to incorporate them into high-density flash memory.

What will this mean for us? TSV chips will be extremely speedy processors, and because chips with different functions can be made separately and later stacked, prices for multifunctional chip stacks will probably drop. One thing is certain, says interconnection expert Larry Smith of Sematech, a consortium that studies semiconductor manufacture: "Products will continue to get smaller, thinner and lighter." —M.W.

THE YEAR AHEAD

SEPTEMBER: Similar to the Nobel Prize, the Kavli Foundation, based in Oxnard, California, will begin awarding \$1-million **biennial prizes** to scientists working in astrophysics, nanoscience and neuroscience.



OCTOBER: Computer-game creator and Space Adventures board member Richard Garriott will be the sixth cosmic tourist the company sends into space. Garriott, whose father is astronaut Owen K. Garriott, has said he may take the **first-ever civilian space walk**. Ticket price: \$45 million.



NEW DIGS FOR BIODEFENSE RESEARCHERS

Officials are set to build the next agro-terrorism research center

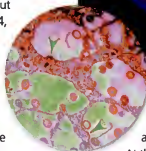
TWO MILES OFF the tip of Long Island, New York, sits an 840-acre island that houses the Plum Island Animal Disease Center. The researchers working inside the Plum Island facility represent the country's front line against such animal diseases as foot-and-mouth. But the Plum Island buildings were built in 1954, and the facility cannot handle some of the pathogens that the Department of Homeland Security (DHS) believes are likely to be used by terrorists as weapons against our food supply and national health.

This October, DHS will select a location for the National Bio- and Agro-Defense Facility, a \$450-million animal and zoonotic (able to jump from animal to human) disease lab to study potential agro-terrorism threats. Six locations are in the running for the 520,000-square-foot facility. Five are on the mainland; the sixth is a new facility on Plum Island. (It's illegal to study foot-and-mouth disease on the mainland, so Congress will have to get involved if DHS chooses one of those five sites.)

In addition to typical agro-disease research, 10



Highly contagious foot-and-mouth virus



percent of the facility will be used for Biosafety Level IV research, the study of lethal, exotic or contagious diseases or agents that pose the most risk to humans.

At the top of the list for such research at the new lab: the Nipah and Hendra viruses, which were discovered recently in Malaysia and Australia and have proven deadly to many of those who've been infected.

"It's all part of the overall threat analysis to mitigate the threat against U.S. agriculture," says James Johnson, the head of laboratories for DHS. "Plum Island has been the front line, but we've got other threats that we need to deal with." —K.P.

NOTABLES OF '08

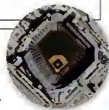


Environmental Disaster THREE GORGES DAM

The Chinese government announced that up to four million more people will be displaced to protect them from further landslides caused by the dam. In addition, the newly tame flow of the Yangtze River is creating a major buildup of pollutants in the reservoir and algae blooms downstream.

Vehicle TESLA'S ELECTRIC ROADSTER

Tesla says it will produce about 600 all-electric sports cars this year. The vehicles will cost around \$100,000, have a range of 245 miles, and do 0-60 in less than four seconds. —K.P.



BUILD YOUR OWN SURVEILLANCE STATE

New satellites take to the skies, and you can buy time on one

THE NEXT GENERATION of private spy satellites is here: *WorldView-1* launched last September, and *GeoEye-1* will launch this April. Their high-resolution cameras are able to spot an object about the size of home plate, but their real advantage is in how much of that data

they'll be able to send back. High-res imaging satellites must aim at a small swath of the Earth as they pass over land; because these new satellites have a wider field of view, as well as improved storage and communication capabilities, each one will cover at least twice the territory of

their predecessors on every orbit. That means more high-resolution images on Google Earth and Yahoo Maps, and more chances for individuals and companies to buy time from the eyes-for-hire in the sky.

—ROBIN MEJIA



NOVEMBER/DECEMBER: Boeing's fuel-efficient **787 Dreamliner** will enter the commercial airline market—if it doesn't get delayed again. More than 700 jets have already been pre-ordered.

END OF 2008: New York City's subway system, the largest in the nation, will start to install **cellphone antennas in six stations** throughout the city. The full project is scheduled to last six years and will eventually wire all 277 underground subway stations at a reported cost of around \$150 million. —K.P.

world trade Center

E Queens Blvd
8 Avenue

PAGING DR. FEAR

If fear really is all in our heads, Joseph LeDoux thinks he can eliminate it. The first step is to block out our memories

BY MICHAEL BEHAR

ILLUSTRATIONS BY MED1-MATION | PHOTOGRAPH BY JOHN B. CARNETT

THREE KEY FACTS

- 1** Fear is controlled through the amygdala, a small chunk of the brain that directly activates your fear response, bypassing the conscious mind.
- 2** By blocking the "fear memory"—the original cause of a given fear—Joseph LeDoux has shown that the fear itself can be eliminated.
- 3** New trials will explore whether drugs can alter specific memories (and the fears they cause) in soldiers and trauma survivors.

WHEN I WAS nine years old, my family moved into a newly constructed home in a pleasant Seattle suburb. Within a few days, I began to notice an unsettling number of spiders creeping along baseboards, dangling in closets, and loitering under furniture. I convinced myself that the assault could only be because our digs had inadvertently razed some kind of spider civilization, and these guys were out for revenge. I remember being unable to sleep, spooked by the sight of an eight-legged nasty clinging to the ceiling, waiting to pounce. I would insist that my father leave the stairwell light on so I could track its every move, certain that under the cover of darkness the little monster would sneak into my bed and burrow into my ear canal, where it would lay its sticky spider eggs and spawn a whole new arachnid dynasty. I stuffed wads

of toilet paper into my ears as a first line of defense.

Fast-forward 30 years, and I find my repulsion firmly entrenched, seemingly for good. On a recent business trip, I glimpsed a spider behind the nightstand in my hotel room. I summoned the concierge, who duly chased the evil critter into the hall with a broom. "No problem," he smirked when I apologized for my wimpiness. "Happens all the time."

There's a proven treatment for phobias called exposure therapy, better known as "facing your fears." I merely have to immerse myself in a bathtub with hundreds of spiders, let the insects crawl freely over my naked body, and voilà! I'll be cured.

Luckily, New York University neuroscientist Joseph LeDoux, the world's preeminent fear guru, agrees that this





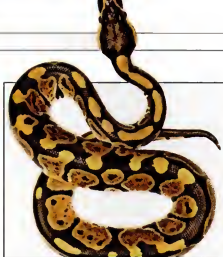
tactic might not be the most efficient remedy. Imagine forcing an aviophobe onto a plane—a severe panic attack could trigger a midair rerouting to the nearest loony bin. But LeDoux may have uncovered a better way. After a two-decade-long pursuit into the depths of the brain, LeDoux has shown that it's possible to eliminate deep-seated fears. All you have to do is remove the memory that created it.

Last year, in a landmark experiment in rats, LeDoux opened a path to doing just that. He showed that it's possible to obstruct the memory of a specific traumatic event without affecting other memories. He also demonstrated that when the memory was stifled, the fear it roused vanished as well.

This sudden ability to produce selective amnesia stunned the scientific community. It also offers unimaginable promise. It could relieve soldiers suffering from post-traumatic stress disorder (PTSD) or rid sexual abuse and rape victims of haunting memories. My spiders would be fair game, as would LeDoux's enduring aversion to snakes. Other researchers have been quick to adapt LeDoux's findings. One has already begun experimenting on human subjects, and a startup company has emerged that plans to eliminate fears in the comfort of your own home. All you need is a mail-order box of pills and the accompanying DVD.

THE SHOCK OF DISCOVERY

Down the corridor from LeDoux's office, near a paper sign reminding students of the lab's Wi-Fi password ("fearisgood"), heavy glass doors open to reveal the fear factory. Inside, 300 plump white rats live like rodent royalty. Each gets its own transparent acrylic cage and is fed a continuous supply of filtered water and top-notch rat chow. Their cages, neatly aligned on stainless-steel wire shelves, are scrubbed regularly and ventilated with oxygen-rich air. When we enter, we have to wear surgical masks to keep from sully the rats with germs we might be tracking in from the outside world. According to Marie Monfils, a postdoc here, these rats are treated exceptionally well because happy,



NOTHING TO FEAR BUT ... According to a recent poll of American adults, we're a nation of ophiophobes (50 percent of the population reports being "very afraid" of snakes), acrophobes (fear of heights, 36 percent), arachnophobes (fear of spiders, 27 percent) and aviophobes (fear of flying, 18 percent).

healthy, easygoing rats make ideal test subjects when it comes time to scare the holy crap out of them.

To understand why rats—and other animals, including humans—get scared, you have to start at the amygdala, the place where sensation and memory join forces to spawn the venerable beast we call fear. The amygdala is buried in the forebrain directly behind the eyes. LeDoux first started researching the amygdala in the late 1970s with early experiments that investigated how rats adapt to danger.

In one experiment, LeDoux played a tone to the rats and then dispensed a mild electric shock. After a few repetitions, the tone alone made the rats freeze—a classic Pavlovian response. He had expected this, but at the same time he wondered what was actually occurring inside their brains when they froze. He injected a dye that mapped out the connections in the rat brains and found that the auditory thalamus—the part of the brain that receives signals from the ears—connects directly to the amygdala. He then surgically cut the pathway that connects the auditory thalamus to the amygdala, repeated the tone, and found that the rats no longer feared the sound.

Somehow, the amygdala was forming and storing what LeDoux labeled a "fear memory" that preempted all other brain activity whenever it recognized the offending input. The rats were essentially oblivious to their freezing behavior, responding to the tone without the use of their higher brain functions, precisely the way I might squeal like a schoolgirl at the sight of a spider before I can reason that it's not going to eat my left arm.

The study revealed that when it comes to fear, the "thinking" part of your brain is instinctively subordinate to the amygdala. Your fears forestall your thoughts, and the amygdala is the reason why. It takes a new input, checks it against your fear memories and, if there's a match, initiates a response.

Without the fear memory, though, the chain falls apart: If my brain can't remember why I'm afraid of spiders, then I won't be afraid of spiders. Yet

AN ATLAS OF FEAR

Fear sets your body in motion, readying you to deal with a threat. But the long-term effects of anxiety and stress can cause serious harm

BY SABA BERTHE

EYES

Fight-or-flight hormones like norepinephrine dilate your pupils to improve vision.

HEART

Your heart pumps faster, increasing blood pressure to accelerate the delivery of oxygen. Prolonged high blood pressure increases your risk of heart attack or stroke.

LUNGS

Your breathing rate increases as your lungs take in more oxygen. Long-term stress responses exacerbate asthma, and hyperventilation can trigger a panic attack.

SKIN

Sweat glands start working to cool the body down. But long-term stress can suppress wound healing, making the body prone to infection.

HORMONES

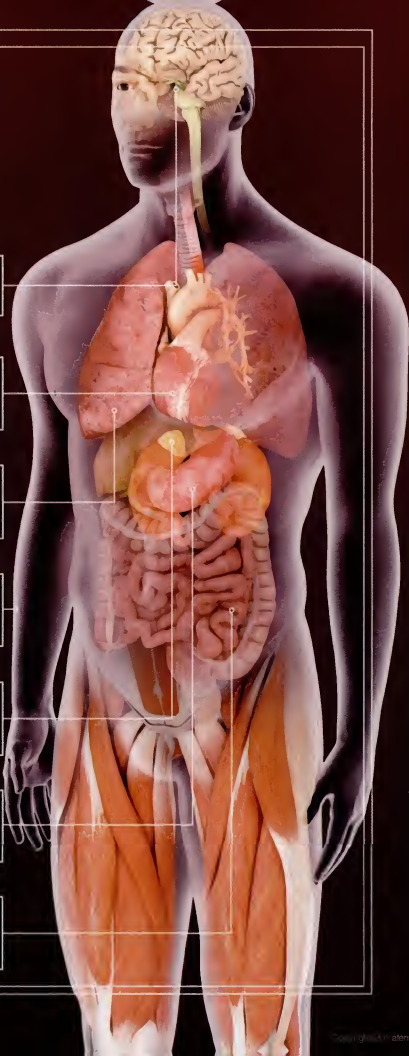
The adrenal glands secrete cortisol, a stress hormone. Too much cortisol corrodes bones and muscles and weakens the immune system, diminishing an immune response.

STOMACH

The stomach stops digesting so the body can divert energy elsewhere. Slow digestion may result in an increase in stomach acid, causing nausea or inflaming an ulcer.

INTESTINES

During a stress response, blood is shunted away from the intestines. Continually suppressed digestion can trigger irritable bowel syndrome.



selectively eliminating a memory would seem to be impossible. LeDoux suspected it was not.

THE YOUNG BRAINIAC

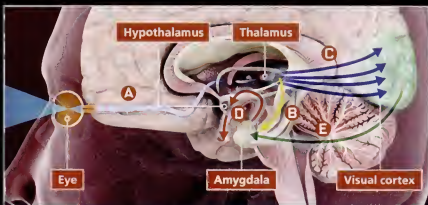
LeDoux is the hippest nerd I know. His salt-and-pepper hair is smartly slicked back, and a soul patch crowns his chin. He's wearing flip-flops, black jeans and an embroidered lime-green shirt with its square-cut shirttails untucked. The rockabilly look is fitting when you learn that he spends most of his spare time jamming with his band, The Amygdaloids, playing guitar, singing, and writing lyrics. Of course, one can only be so hip: Most of their songs are about neuroscience.

We're sitting at a round conference table in his office on the 11th floor of NYU's Center for Neural Science, where LeDoux is giving me the Fear 101 primer. The 58-year-old's Cajun accent, though refined, still lingers from an upbringing in Eunice, Louisiana, where he raised prize-winning cows, bulls and horses and aimed to become a priest. "I went to Catholic school, and the nuns thought of me as their pet project," he recalls. "I made rosaries and was the altar boy. I used to hold mass in my bedroom by myself, just to practice. But in eighth grade, the hormones kicked in and I started thinking more about girls than religion."

He first started tinkering with brains at his father's butcher shop. "In those days, they would slaughter the animal by shooting it," he says. Pops tasked the young LeDoux with digging through cow brains, a local delicacy, to retrieve the bullet, because "you wouldn't want to chomp down on a piece of lead." While poking around in the mush, LeDoux remembers pondering its purpose. "I'd reach in there and would always be thinking about what each part does."

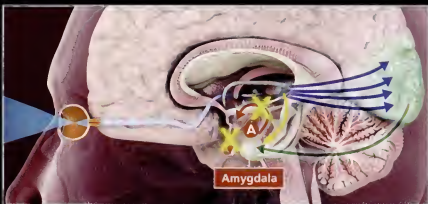
LeDoux was one of only three people from his 1967 graduating high-school class to leave the bayou for the big city—Baton Rouge. He enrolled at Louisiana State University and begrudgingly obliged his parents' desire for him to study marketing. After all, they were paying the tuition. But his budding interest in the mind led him to study consumer psychology, where he

WHAT FEAR DOES TO THE BRAIN



Say you're afraid of mice. When the eye sees one skitter, it transmits the data to the thalamus [A], which sends the information straight to the amygdala [B] and the visual cortex [C]. The amygdala rapidly associates the image with a fear memory and tells the hypothalamus [D] to prime the body for action. Meanwhile, the visual cortex goes through the higher-level processing of the image, but rationalization [it's just a mouse!] is too late [E] to overcome the amygdala's immediate response.

HOW ONE DRUG FIGHTS FEAR



A drug called d-cycloserine [DCS] helps to inhibit long-held traumatic fears. The drug boosts NMDA receptors in the amygdala, which helps it to form new memories. Watching a video of what you fear while under the influence of DCS writes new, strong memories to the amygdala that aren't associated with a traumatic event. Thus, when you see a mouse again, the amygdala doesn't initiate a fear response [A].

mused about how it might be handy for understanding consumer behavior. (At one point, LeDoux wrote a letter to B.F. Skinner asking the eminent psychologist what he thought of the concept. Skinner replied, scolding it as unethical. Today you'd be hard-pressed to find a single major ad agency that doesn't have a consumer psychologist on staff.)

LeDoux went on to get a master's degree in marketing. But a course he took taught by LSU psychologist Robert Thompson that examined the roots of

memory convinced him to become a lab scientist. He applied to Ph.D. programs in biological psychology—12 in all, to ensure that he got accepted somewhere. (His grades weren't stellar, LeDoux says: "I got hooked up with people in college who showed me the good life.") He ended up at the only school that accepted him, the State University of New York at Stony Brook.

At that time, scientists scoffed at the idea that emotions and fear dwelled in some kind of tangible neural mesh



hidden in the brain. They believed that emotions were complex psychological phenomena that, for the most part, had little to do with what LeDoux imagined as rogue bits of brain circuitry. But he suspected that he could understand human emotions by starting small.

Because fear was easy to isolate—a raw and universal emotion that spanned all species—it seemed like a sensible thing to tackle first.

In the 30 years since grad school, as a professor at Cornell University Medical College and later at NYU, LeDoux has become the undisputed King of Fear, having written two acclaimed books and published dozens of groundbreaking studies based on the simple premise that memory and fear are, in fact, inextricable soulmates.

ELIMINATING MEMORIES

LeDoux populates his lab with kindred thinkers, resourceful polymaths who can draw from multiple disciplines to arrive at unforeseen solutions. There are people like Monfils, who explains to me how she programmed rats to forget their fears while she cradles one of the rodents in her arms, stroking its white coat as if it were a cuddly housecat. This rat, it should be noted, is one she has “modified”—the top half of its cranium

“YOUR MEMORY OF AN EVENT IS ONLY AS GOOD AS YOUR LAST MEMORY OF IT,” LEDOUX SAYS. EVERY MEMORY CAN CHANGE.

looks like it has been sliced off, and in its place sits an implantable microchip that lets Monfils watch its brain activity in real time on her laptop PC.

In a study published in *Nature Neuroscience* last year, LeDoux’s team repeated the tone experiment, except this time there were two tones: a high-pitched beep and another like a digitized cricket. The rats heard both tones 20 times and then got a shock. This sequence was repeated three times, enough for the rats to learn to fear the tones as before. Now it came time to break the memory and, hence, the fear. While only the cricket tone played, the rats were injected with U0126, a chemical that prevents long-term memories from forming. Twenty-four hours later, when the rats heard both tones again, they froze only after listening to the beep. The drug had flushed away any memory of getting shocked after hearing the cricket noise—and no memory meant no fear.

The study joined a growing chorus of research demonstrating that memo-

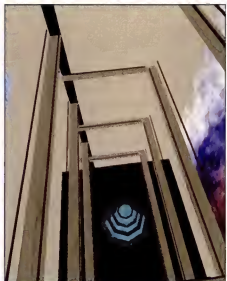
ries aren’t immutable objects encased in museum glass. Rather, they are living, changing things and can be manipulated whenever evoked. “It sounds like science fiction, but long-standing memories are vulnerable to change,” says LeDoux.

More important, it also proved that a specific memory could be altered or erased (remember, it eliminated just the rats’ fear of the cricket, not the beep). The rats remembered getting a shock after hearing the cricket tone, and so they froze whenever it was played. U0126 blocked that fear memory, but only because the drug was dispensed when the rats were prepared to get the shock again. “Your memory of a specific event is only as good as your last memory of that event,” LeDoux says. Thus, every time you dredge up a memory, good or bad, it’s susceptible to change. (Incidentally, this is how neuroscientists account for “alien abductees” who pass lie-detector tests. The victims recall their close encounters so exhaustively and so often that the repeated recollections gradually alter the memory until the fabrications become indistinguishable, neurochemically speaking, from truths.)

News of LeDoux’s experiments spread, and the neuroscience community quickly took notice. The conventional practice of “talk therapy” suddenly seemed tedious and of dubious efficacy. Why would I want to spend hours of couch sessions with my shrink when a shot of an amnesia-inducing compound into my brain at the exact moment I’m remembering my childhood spider invasion would make me fearless in an instant?

“When you recall something, you don’t recall what originally happened; you recall what you recalled the last time you recalled it,” explains Roger Pitman, a professor of psychiatry at Harvard Univer-

ICONTINUED ON PAGE 621



VIRTUAL THERAPY Researchers are testing memory drugs to help veterans who suffer from post-traumatic stress disorder. Virtual-reality simulations (left), aided by a drug that helps memory formation, work to disassociate thoughts of battle from the real trauma of warfare. In the future, videos of heights (for example) could help cure ordinary fears (right).

The United States Marine Corps

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In the Marine Corps, today's leaders have tomorrow's technology at their fingertips. Here's what makes the world's first production tiltrotor aircraft such a powerful force.

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Equally comfortable in dusty zones and cruising the airways at 15,000 feet.

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THE WORLD'S BIGGEST TELESCOPE

About half the size of a football field and 21 stories tall, the largest optical telescope ever constructed will use almost 1,000 mirrors to hunt for exoplanets—and maybe even unlock the secrets of spacetime **BY BJORN CAREY**

HOW TO CAPTURE THE COSMOS

1. COLLECT THE LIGHT

Starlight hits the 138-foot-wide parabolic **PRIMARY MIRROR**—an array of 984 hexagonal panels, each one 330 pounds, 4.8 feet in diameter and two inches thick. The panels are so heavy that gravity actually causes them to shift very slightly as the scope moves, so three actuators under each panel flex 10 times per second to keep the mirror properly aligned. The light bounces up to the 20-foot-wide **MIRROR A**.

2. REFLECT IT

MIRROR A reflects and inverts light through a hole in **MIRROR C** onto the 13.8-foot **MIRROR B**, which directs light up to the reflective surface of **MIRROR C**.

3. SHARPEN IT

MIRROR C is a thin two-millimeter glass shell stretched over 5,000 actuators that

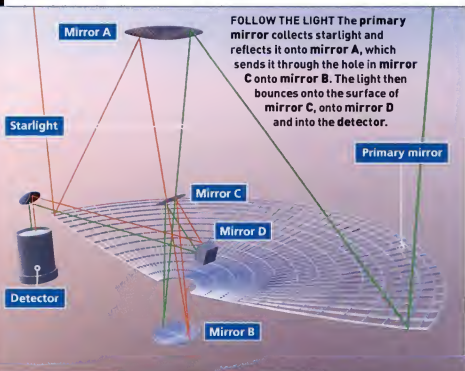
push or pull to reshape the mirror's surface 1,000 times per second. This rapid action performs so-called adaptive optics—realigning light distorted by the atmosphere into a sharp image. Astronomers calculate the correct setting for this mirror using bright reference stars [see "Calibrating a Giant Scope," right].

4. SEND IT TO A SENSOR

Once corrected by the adaptive optics system, the light hits **MIRROR D**, 8.9 feet in diameter, which moves up to 20 times per second to keep the reference star aligned against vibrations from wind hitting the structure. This mirror reflects the starlight to a **DETECTOR**, which houses a camera that captures images, and to instruments that astronomers use to measure such phenomena as the speed at which the universe is expanding.

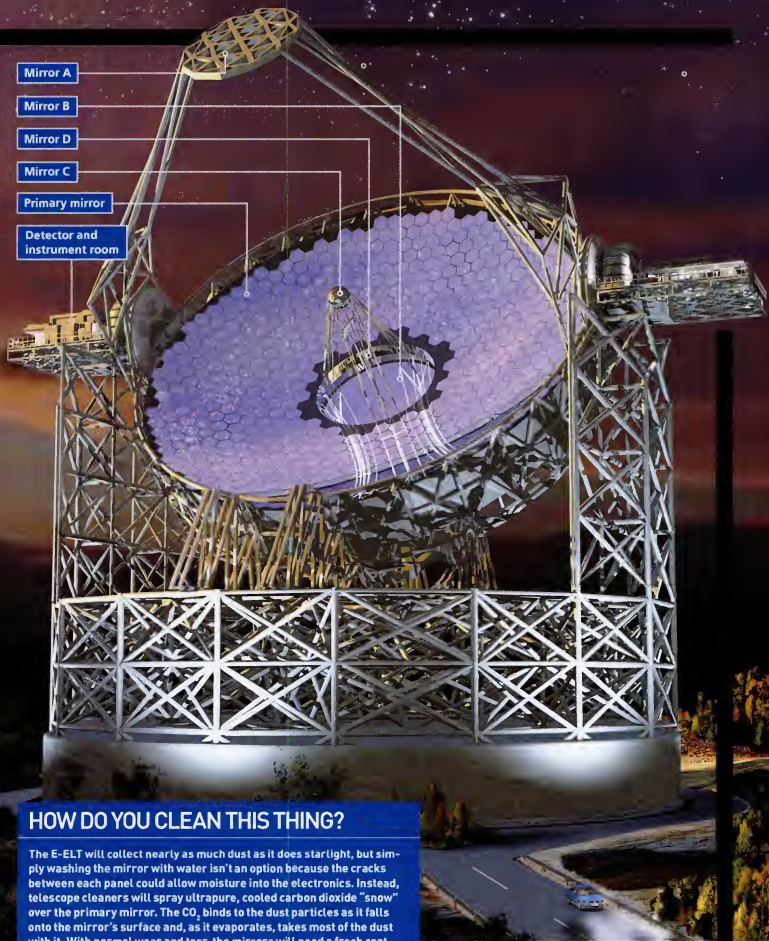
CALIBRATING A GIANT SCOPE

Atmospheric turbulence and airborne particles scatter starlight as it heads toward ground-based telescopes, so astronomers calibrate the European Extremely Large Telescope's optics using bright reference stars in the same field of view as the target object. The rippled light wave hits each pixel on mirror C at slightly different times. The adaptive optics system morphs the mirror's surface so that the light hits each pixel at the same time, creating a clear image. But if an object has no nearby stars, astronomers make their own reference stars: Five or six lasers, known as a laser guide-star system, excite sodium ions 56 miles up in the atmosphere to create artificial beacons.



THE EUROPEAN EXTREMELY LARGE TELESCOPE (E-ELT)

BUILT BY: European Southern Observatory
SITE SELECTION: Will choose site by late 2008, probably in the Southern Hemisphere
CONSTRUCTION STARTS: Early 2010
FULLY OPERATIONAL: 2017
DESIGN COST: \$81.3 million
CONSTRUCTION COST: \$1.1 billion
IMAGE RESOLUTION: 10–15 times as sharp as Hubble
PRIMARY MIRROR: 138 feet wide
NEXT BIGGEST SCOPE: The Gran Telescopio Canarias in the Canary Islands (34 ft.) and the Thirty Meter Telescope (98 ft.), scheduled for completion in 2016 (site undetermined)



Mirror A

Mirror B

Mirror D

Mirror C

Primary mirror

Detector and
instrument room

HOW DO YOU CLEAN THIS THING?

The E-ELT will collect nearly as much dust as it does starlight, but simply washing the mirror with water isn't an option because the cracks between each panel could allow moisture into the electronics. Instead, telescope cleaners will spray ultrapure, cooled carbon dioxide "snow" over the primary mirror. The CO₂ binds to the dust particles as it falls onto the mirror's surface and, as it evaporates, takes most of the dust with it. With normal wear and tear, the mirrors will need a fresh coating of reflective material, most likely aluminum, every few years.

THE GATHERERS

Around the world, scientists are risking their lives to retrieve seeds destined for a massive vault near the North Pole. Their work just might save mankind

BY HILLARY ROSNER
PHOTOGRAPHS BY ANDREW McCONNELL

TO VISIT THE SHOLA MARKET, a teeming maze of stalls in Addis Ababa, Ethiopia, you'd never know that the human race's food supply was in jeopardy. Massive sacks stuffed with dried chili peppers overflow onto piles of vegetables—potatoes, beets, carrots, onions, tomatoes. Enticing smells waft from the spice sellers' stalls, crowded with colorful mounds of cumin, turmeric and ginger.

Wandering the market's muddy corridors, Luigi Guarino stoops to smell frankincense and examine fistfuls of legumes. To the casual observer, they're just sacks full of beans. But to the 48-year-old crop scientist, each one is a tiny buffer against worldwide starvation. Guarino fingers the dried seeds with reverence, because he understands how valuable—and fragile—they really are. He has spent much of his career trolling remote and exotic lands, gathering the genetic diversity of the plants that sustain humanity. His work has taken him to roadless villages in Oman's mountains and across the desolate Sahara between Algeria and Niger, all in search of crop varieties with unique traits that could someday save the world's harvest—and its people—from infestation, blight or drought.

Looking up, Guarino explains that in certain countries, industrial progress has left some of the world's most important food crops at risk of obliteration. When it comes to

gathering food, "people used to be more mobile," he says, as the beans sift through his fingers. "Now they have nowhere to go. They're more vulnerable to things like drought. As population increases and more farmland is converted to urban areas, you have less land on which to produce more food."

Meanwhile, because the efficiency of modern farming has made crops so genetically uniform, the plants on which humans depend—those we've bent to our will over thousands of years—are at the mercy of chance. They simply aren't diverse enough anymore. To endure, crop plants, like their wild counterparts, need varied gene pools. But the genetic diversity of our food supplies is withering. In the past 200 years in the U.S. alone, 75 percent of the variety within crops has vanished. That's a disaster waiting to happen.

To help prepare for the worst, in February the Norwegian government, together with the Global Crop Diversity Trust, an organization in Rome for which Guarino now serves as science coordinator, will unveil an immense fortress, the Svalbard Global Seed Vault, built on a frigid, wind-whipped archipelago in the Arctic Ocean, 600 miles from Norway.


The Crop Trust's mission is to safeguard agriculture, and it has raised more than \$130 million of a \$260-million goal to do so. It plans to permanently endow a network of seed and

SEEING DANGER Luigi Guarino in Ethiopia



THREE KEY FACTS

- 1** Having a variety of genetic material within crops means when infestation or drought hits, those plants are able to adapt and survive.
- 2** In the past 200 years, 75 percent of plant variety has disappeared from U.S. crops, a trend that endangers humanity's food supply.
- 3** A group of plant scientists are traveling the world to collect seeds for a doomsday vault on a frozen Arctic island—a last option in case disaster strikes.



SEEDS OF CHANGE A handful of safflower at the Shola Market. Even in Ethiopia, which has managed to preserve the greatest amount of natural diversity within its plant life, crops are becoming more homogenous—and thus more vulnerable.

PROPOSITION: Will there be an urgent withdrawal from the Svalbard vault in its first year?

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gene banks—archives of essential plant materials—around the world. The Svalbard vault is its ultimate defensive measure: a last-ditch reserve, ready if all else fails.

Dug nearly 400 feet deep into a sandstone mountain, the vault's interior temperature is immune to changes in the surrounding permafrost. It sits roughly 425 feet above sea level, protected against flood even if all of Antarctica were to melt. The entry tunnel passes through a series of steel doors and a highly sophisticated video surveillance system before reaching three chambers capable of holding 4.5 million samples of vital crop seeds. Safe from nuclear warfare, terrorist attacks, natural disasters and global warming, the seeds stockpiled at Svalbard just might revive our food stores in the event of a global catastrophe. Svalbard's feasibility study, conducted by an international team of scientists, concluded, "Our existence on earth rests on how well we take care of these seeds; and their existence depends on us."

But before they can be dehydrated, sealed in special foil packages, and laid in their frozen resting place, the seeds must first be collected in the field. Guarino is part of a small but dedicated band of such seed collectors.

They're a far-flung bunch. From Aleppo, Syria, where he curates one of the most important collections of wheat and the wild ancestors with which it shares genes, an intrepid Australian named Ken Street leads annual expeditions across lawless tracts of central Asia and the Caucasus in search of new genes for dry climates. Daniel Deboucq, an ebullient Belgian scientist based in Cali, Colombia, has spent three decades roaming the Americas on the trail of unique beans. "He's married to the bean," Guarino jokes, "but recently he had an affair with a cassava." And dozens of other crop scientists, botanists and biologists each struggle, on meager budgets, to retrieve seeds from similarly remote and dangerous regions.

WHY DIVERSITY MATTERS

If the word "biodiversity" triggers any associations for you, they probably have to do with rainforests and gorillas, not fields of neatly planted corn, peas and pineapples. But agricultural crops are subject to the same basic laws of biology and natural selection as all living things. To adapt and evolve, to survive disease and adjust to changing environmental conditions, their gene pool must be a mixed bag.

Crop yields will need to roughly double in the next 50 years to keep up with the pace of population growth. As a result, protecting agricultural biodiversity is more important than ever, and the preservation of raw material necessary for crops to adapt is "the most fundamental thing you can do to ensure their survival," says Cary Fowler, a native Tennessean who is the Global Crop Diversity Trust's executive director and the main visionary behind Svalbard.

The raw genetic materials are stored in gene banks all over the world as seeds, plant tissue and whole plants,



DEEP STORAGE North of mainland Norway, two security doors and three airlocks protect the cave's contents.



FAR AFIELD Ken Street gathering wheat in Armenia

which these banks then loan out. Farmers and breeders can obtain plant material to grow in the field or to use for breeding specific traits. But these banks are also an archive, and preserving the genetic material is a complex undertaking. Some seeds can survive frozen for decades but must still be periodically thawed, tested for viability, and regrown—a time-consuming operation. Other plants don't respond well to the drying and freezing process. Apples, for instance, should instead be cryogenically frozen, an expensive effort impossible at all but the best-funded gene banks, like the U.S. Department of Agriculture facility in Fort Collins, Colorado. Coffee plants, meanwhile, need to be continuously grown in the field. And still more plants are cultured and stored in test tubes, which takes a great deal of time and money.

Preserving crop plants in gene banks is a hedge against unknown future threats. It ensures that diversity will be there when breeders need it to breed plants that are tolerant of saltier soils, for example, or resistant to invading insects. "You don't actually know what will be needed by what country when," says Julian Laird, the Crop Trust's director of development. "It could be in Rwanda or it could be in Colorado."

Gene banks are one of the few reliable sources of plant material that might save the day. A breeder whose country faces a particular infestation will need to experiment with

**MANY OF TODAY'S GENE BANKS ARE PLACES WHERE
"YOU WOULDN'T STORE A KID'S MILK FOR LUNCH."**



UNTIL THE END OF THE WORLD

THE VAULT can store 4.5 million seeds within its reinforced-concrete walls, dug nearly 400 feet into the mountainside. A ventilation system will pump in Arctic air when it's cold enough; if the temperature in the vault rises above -0.4°F , a complex

refrigeration system will kick in. A fiber-optic monitoring network will keep close tabs on climate conditions and transmit images of the vault's interior to the University Center in Svalbard and to the nearby Nordic Gene Bank.

a wide variety of genetic material within that crop to find a resistant gene. "My job," Street says, "is to put together big gene pools so that breeders can dig into them." Street's facility in Syria may look like nothing but a tidy storehouse for a few crops, he explains, but within that collection there's a wide variety of genetic material. "Wheat from the highlands of Ethiopia is likely to be very different than wheat from the highlands of Turkmenistan because they evolved to be quite different—just as you have a Pygmy perfectly adapted to running through a forest and a Dinka adapted to running through the plains."

An international network of gene banks called the Consultative Group on International Agricultural Research (CGIAR) stores collections of many crops, with funding from the World Bank, the Food and Agriculture Organization of the United Nations and others. Debouck and Street each curate CGIAR centers, which serve as a home base for their field expeditions. Many countries also maintain their own gene banks, and those sometimes house the only specimens of a particular seed variety.

Similarly, the Global Crop Diversity Trust is trying to create a linked chain of gene banks by endowing the most important of them around the world. "Gene banks are clearly one of the basic building blocks of a healthy agricultural system," says Roy Stein, a senior program officer in agricultural development at the Gates Foundation, which gave \$30 million to the Trust. "It's this library that nature has given us from millions of years of evolution, and the fact that we're allowing these incredible books to be lost is a tragedy."

Gene banks tend to be underfunded, disorganized, and located in hard-luck places, partly because much of the planet's genetic diversity arose in what are now the poorest countries. Many of the 1,400 facilities around the world that describe themselves as gene banks are, Fowler says, places

"where you wouldn't want to store a kid's milk for lunch."

Before it gained notoriety for its prison, Abu Ghraib was the site of Iraq's national seed bank. It was destroyed and looted after the 2003 American invasion, its collections of lentils, rye, barley and other seeds gone forever. Afghanistan's seed bank was obliterated during mujahadeen fighting in the 1990s; a clandestine seed collection established afterward and hidden in a private house in Jalalabad was also looted—robbed for the plastic bottles used to store the seeds. In 1985, a starving group of homeless people broke into Peru's National Agricultural Institute and made off with its sweet-potato collection. Last year, a typhoon washed away the Philippines's gene bank—countless variations of sweet potato, taro and banana carried off in a river of mud.

What did we lose, exactly? It's impossible to say. "The problem in explaining it to the public," Fowler says, "is we don't know what was lost. And you can say, 'Well so what?' And I can't answer, 'Well, what we've lost was the last form of resistance to a disease that we're going to encounter five years from now.'"

SAVING THE WORLD, INVISIBLY

The foot soldiers of biodiversity have an extraordinarily important mission, but the particular irony of their efforts is that if things turn out as they hope, and the biodiversity of plant life is preserved, the material they bring back to the impenetrable vault in Norway will never truly be needed. If all goes well, no one will know the lengths to which scientists like Guarino and Fowler went.

Anonymity and thanklessness have always been part of this work. Across the sprawl and chaos of Addis Ababa from the Shola Market is the Institute for Biodiversity Conservation. Guarino has come to Addis with Fowler to discuss an endowment for the Ethiopian national gene bank and its

relationship with the Svalbard vault. For three hours, the two men sit with a group of Ethiopian officials, sipping thick sweetened coffee and snacking on roasted barley as they hammer out an agreement to ensure the continued safety of the country's collections of nine crucial cereal crops.

Downstairs, the objects of their attention are waiting, vacuum-sealed and frozen: wheat, sorghum, teff (the grain used to make Ethiopia's national bread, *injera*). Up to 400 species of these and other crops are housed here, 60,000 bags, each containing between 3,000 and 8,000 seeds from the same species and location. Ethiopia has retained the largest amount of traditional diversity of any country. Several of the crop varieties stored here are extinct in the fields and exist only within these walls, in one of the world's poorest countries, on the planet's most volatile continent.

In the lobby of the Addis gene bank is a life-size photograph of Nikolai Vavilov, the Russian botanist who in the early 20th century developed a landmark theory about the origins of cultivated crops. Gene banks tend to have a shrine to the man somewhere on the premises. The area where a crop has had the most time to evolve, Vavilov posited, will be the area where that crop contains the greatest breadth of genetic diversity, and therefore the area you'll want to visit if you're seeking a particular trait to breed into the plants. If, for instance, Ireland's genetically fragile potato crop is hit with a crushing blight, kicking off widespread famine, a gene for resistance would logically be found in the Andes, Vavilov reasoned, where the potato originated and where there are several thousand known varieties of the tubers.

Today, crop scientists still rely on Vavilov's notion of "centers of diversity" and hail him as both a hero and a martyr. He spent his career crossing places like China, Bolivia and Abyssinia (modern-day Ethiopia) on foot, camel and donkey, gathering what was at that time the world's largest collection of seeds, both cultivated and wild, for conservation. The genetic diversity contained in those seeds, he believed, represented humanity's hope for survival. But politics got in the way of his work. Stalin wanted nothing to do with genetics, and Vavilov's progressive ideas amounted to heresy. In 1940, in his early 50s, Vavilov was jailed for pursuing "impractical science." Three years later, he starved to death in prison.



UPROOTED "This is the only world problem we know we can solve at this point in history," says Cary Fowler, the man behind Svalbard.

RATHER THAN EAT THEIR SEEDS, THE SCIENTISTS CHOSE STARVATION.

Vavilov wasn't the only Russian scientist who died in the name of crop diversity. During the 872-day Nazi blockade of Leningrad, Vavilov's colleagues holed up inside the gene bank he founded, determined to protect the seed collection from the Germans and the city's hungry residents. There, locked inside a building filled with seeds, roughly a dozen scientists died of starvation.

"The rice breeder literally died sitting at his desk with bags of rice," says Fowler, shaking his head. "I remember visiting the Vavilov Institute in 1985 and trying to understand what had gone on in this building that people would starve to death rather than eat food on their desks." He posed the question to a woman then connected to the Russian institute. "She looked at me quizzically and said, 'They were students of Vavilov.' As though that explained it all."

WHAT IT TAKES TO BE A SEED HUNTER

Each seed gatherer involved with Svalbard is particularly passionate about plants from certain parts of the world. For Street, the Caucasus represents a potential goldmine of genetic diversity both because it's a Vavilov center of diversity (a "rich genetic soup") and because the Iron Curtain left the region essentially cut off from the West, so it's underrepresented in gene-bank collections. His current preoccupation is "plugging eco-geographic gaps": pinpointing areas where particular plants grow and might have interesting genetic variations but have not yet been collected.

One such gap in Street's CGIAR collection is the wild cousins of the chickpea, which happen to grow in very inhospitable areas. "Relatives of the chickpea are distributed in

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Choose your favorite style: the on-ear QC3 headphones or the around-ear QC2 headphones. And discover the unmatched combination of noise reduction, audio performance and comfortable fit provided by Bose QuietComfort headphones.

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Clearer music. These are our best-sounding headphones. Even delicate nuances, like the soft trill of a flute, are more distinct and natural. Writing about the QC2 headphones, *Travel + Leisure Golf* says, "Forget 'concertlike' comparisons;

you'll think you're onstage with the band." The QC3 and QC2 headphones are also easy to take with you, since they fold flat for easy storage in a slim carrying case.

Two styles to choose from.

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southeast Turkey"—bordering Iran and Iraq—"which is kind of dangerous," he says. "And then there's the bottom of the Caspian Sea in Iran, where it's difficult to get in because they're touchy about foreigners running around." When he heard rumors of wild chickpeas growing in the republic of Georgia, a highly unstable former Soviet territory, he planned a trip to the region anyway. He describes it the way a CIA operative might: "The mission was targeted to grab these wild relatives."

Street's "missions" involve driving clunky old Russian jalopies through deserts or over mountain passes—wild and woolly lands where Kalashnikovs are common and where the police demand constant bribes, sometimes by force—to distant villages where camel's milk is plentiful but outsiders are rare. "We come in, and it's as if a UFO has landed," he says. "All these guys jump out of the trucks with their hats and cameras, and the villagers are like, 'Who are these dudes?' But they always offer hospitality, and vodka."

Debouck's work has sharpened his skills as a detective. In the 1980s, he was on the trail of gigantic lima beans that grow in Peru and Bolivia, kin to certain North American varieties. Conversations with farmers about the relative bitterness of their beans, images of beans painted on ancient

THE GATHERERS ARE WORKING TO PROTECT US FROM OURSELVES.

pottery, and examinations of wild lima beans growing at the edges of farmers' fields combined to lead Debouck and his team to a discovery about the origins of lima beans. "We were able to provide the physical evidence that you had two domestication events for lima beans," he says proudly. "One in meso-America and one in the Andes."

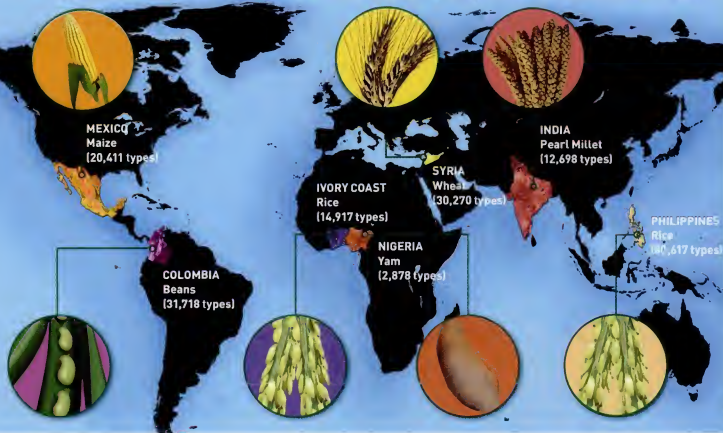
Debouck's bean collecting has taken him through the fields and forests of much of the Americas, scouring the ground in search of uncataloged species. He also combs the collections of the world's top herbaria. Several years ago, while rummaging through an herbarium in Paris, he stumbled on a misplaced specimen: a bean from North America lost in a box of woody plants from all over the world. "I realized that that plant was collected by a French explorer, exploring an area from Florida to the area that is today Quebec," he says. "It might even be a new bean species for the eastern United States."

He is currently tracking a wild bean that grows only in southern Florida. Luckily, one area is protected public land, making it possible that some of the

(CONTINUED ON PAGE 91)

SEED BANKS AROUND THE WORLD

The Svalbard vault will hold backup copies of the world's plants. Currently, far-flung and vulnerable seed banks around the world are the last defense for plant diversity within important regional crops.



An unfair comparison

ht⁷⁴⁵⁰ Zero Gravity Massage Chair



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Lumbar Heat:

A treat for tired lower-back muscles.

Access:

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Value:

25 years of massages built into every chair.

Björn Lindquist – Masseuse



Body position:

... face up or face down.

Comfort settings:

Björn comes with only one
comfort setting.

Lumbar Heat:

... no heated rocks after "the accident."

Access:

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Value:

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... think second mortgage.

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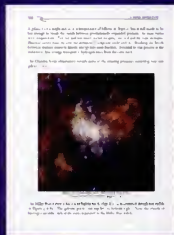
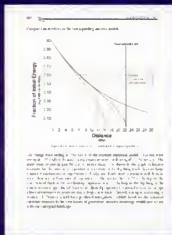
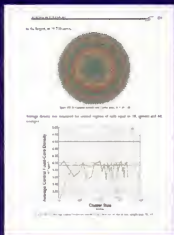
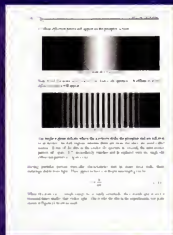
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HOW 2.0

TIPS, TRICKS, HACKS AND DO-IT-YOURSELF PROJECTS



72

A news reader that gets data from your PC



74

Grind titanium to produce brilliant sparks



76

Use your cellphone to get your PC online

YOU
BUILT
WHAT
?!

USING THE FORCE

A group of rocket enthusiasts launches a *Star Wars* replica that would make George Lucas proud

SITTING IN the California desert, Andy Woerner's rocket-powered replica of a *Star Wars* X-wing fighter looks fully prepared to make a run at the Death Star. But for Woerner and his rocket club, building the ship was as big a challenge as what the rebels faced in that galaxy far, far away.

With no specs, they started by measuring a circa-1980 toy model. From that they designed their 21-foot-long plywood version using a CAD program. No detail was overlooked—for example, to get the four 60-pound wings to open and close like the movie's fighter, they took a tiny 2.3-horsepower electric motor from a radio-controlled helicopter and linked it to a complex series of gears, chains and shafts.

Unfortunately, the real Force affecting

the X-wing at the desert rocket show was gravity, and when it began flying erratically, the group had to blow it up by remote control. Still, Woerner hopes he instilled a love of rocketry in the many kids who got to sit in its cockpit beforehand. No doubt, as Yoda might say, an unforgettable experience, it was. —GREGORY MOORE



A LONG TIME AGO... The ship was built to honor the 30th anniversary of *Star Wars*.

THE H2WHOA CREDO: DIY CAN BE DANGEROUS.

We review all our projects before publishing them, but ultimately your safety is your responsibility. Always take proper safety precautions, and follow all laws and regulations.

HOW IT WORKS

2 MONTHS | \$7,000

CO-PILOT

Using an inflatable ball as a frame, the group made a fiberglass mold of R2-D2's head, sat it on a plastic turntable, and hooked that up to the motion system from a radio-controlled boat so they could turn the head from a distance.

LANDING

Just before the rocket reached roughly 700 feet, a series of charges was supposed to release four parachutes—on the wingtips, the nose and the tail—allowing the fighter to land intact.

SELF-DESTRUCT

When the rocket veered on its ascent, the team activated the parachute charges all at once via radio control, turning it into a fiery mess of plywood and parachutes, while keeping it away from the crowd.

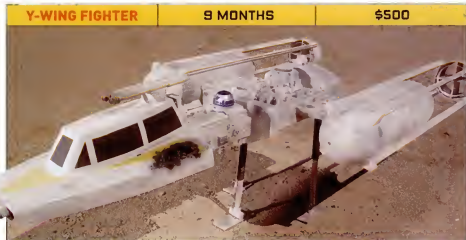


CONTINUED ON PAGE 701



CONTINUED FROM PAGE 69

MORE STAR WARS REPLICAS



TODD MULLIN and the club Punk Rocket Science chose to fashion a rocket from a different rebel ship, the Y-wing fighter. They found drawings and blueprints online and began by building and flying an 18-inch scale model. Then they made a 13-foot-long version from plywood, with cardboard tubing for the

rockets. Paying meticulous attention to detail, the group even smeared black paint over a coat of white for that grungy Star Wars look. They also added fiberglass and fine-sanded the pods on each side [the Y-wing doesn't actually have "wings"] for durability and hooked up a parachute ejection system.

Once the altimeter registered an increase in pressure, indicating descent, the parachutes would pop. Sadly, it never got that far. After liftoff, the charges controlling the chutes blew early, causing the pieces to crash to the ground and giving the Empire the last laugh.

Details at punk-rockets.com

R2-R9 DROID	
3 YEARS	\$12,000

ENGINEER JERRY GREENE built this R2-R9 droid, seen in *Episode I* of the *Star Wars* series, because, he says, everyone makes R2-D2s. Working with the members of an international droid-builders club, he drew up blueprints and then machined and cut the parts of his all-metal robot. Using an R/C helicopter remote, he can steer it, activate a fog machine inside to simulate a smoky breakdown, and even play various

audio clips. A flash drive storing prerecorded R2 sounds from the movies is hooked up to a sound card and a pair of speakers hidden behind two vents. And yes, the kids—and adults—love it.

Details at r2-r9.com



ULTIMATE LIGHTSABER	
1 WEEK	\$175



WHAT'S THE POINT of having a lightsaber if you can't duel with it? Tired of mass-marketed sabers that were constantly breaking, Alex Buckner decided to redesign them. Rather than stringing the lighting throughout the plastic blade, as the official commercial version does, he placed a powerful LED in the handle so that aggressive Jedi throwdowns wouldn't damage it. Now he makes the lightsabers full-time and offers inexpensive DIY kits for aspiring knights and lords.

Details at shop.ultrasabers.com

5 THINGS...

YOU CAN CREATE WITH YOUR PHOTOS

1 A COMIC STRIP

Let 'em know what you were really thinking in that photo. Upload your shots to pikistrips.com, and turn them into a multipanel comic, complete with thought and speech bubbles. You can even add glasses, beards or funny outfits. Then save your creation on the site for the whole world—or just your friends—to see.

2 A MOSAIC

Transform any image into a poster-size mosaic made up of other photos—your own or others from the photo-sharing site Flickr—with mosaicr.com. The site assembles the shots in a few minutes and gives you a free low-resolution version of the final image or a print-ready file for about \$1.30.

3 A COLORING BOOK

Let the kids give themselves green hair by making colorable outlines from family photos. Head to photography blog fototiller.com for an easy three-step tutorial that just requires applying Photoshop's Photocopy filter and adjusting some settings. Print the results, and staple several together.

4 WALLPAPER

Cover a whole wall with any photo, using only your home printer. *Block posters.com* will enlarge your shot to almost any size and automatically split it into letter-size tiles that you can print and tape together. Or leave large seams for a cool paneled effect.

5 CAKE ICING

kingimages.com generates edible cake- or cupcake-size icing sheets from a single photo or a collage and lets you add text. The finished product can last unrefrigerated for up to six months. (Cake not included.)—MIKE HANEY

No more spark.



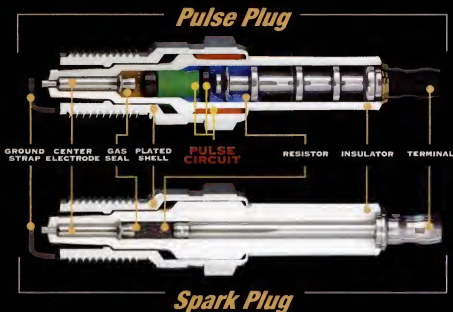
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Spark plugs have changed little over the last 100 years. Conventional wisdom assumed that they were sufficient to efficiently ignite fuel. Pulstar™, a breakthrough in ignition technology, is a drop-in replacement for spark plugs. Pulstar™ pulse plugs generate more than 10 times the power of any spark plug available today. This visibly robust spark ignites fuel differently, allowing for a more complete burn than is possible with spark plugs. More efficient ignition yields improved engine performance and fuel economy.

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Pulse plugs are different. They may look similar to spark plugs on the outside, but inside the technological advances of Pulstar™ are evident. Pulse plugs feature a unique capacitor-based pulse circuit that captures energy wasted by spark plugs and generates a spark 10 times greater than any spark plug.

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PULSE PLUG



AT 033187 USEC



Pulse plugs work differently. Pulstar™ Pulse Plugs burn fuel more efficiently than spark plugs. In freeze frames from a high-speed video, you can actually see the ignition plume of Pulstar™ growing at more than twice the speed of the spark plug. This faster ignition generates more pressure in the cylinder and greater torque to the crankshaft.

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BUILD IT

THE INFORMATION BOX

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YOU'RE EXPECTING an important e-mail at any moment. But how can you possibly go to another room to check your computer when the game is going into double overtime? Not to worry. With a small readout connected via Bluetooth, you can get e-mail alerts, weather reports and plenty of other data from your PC, without ever having to get up off the couch. The

"Feeder Reader"—it also shows RSS feeds on its retro-cool vacuum fluorescent display—draws power from a lithium-ion battery you can charge by plugging into your computer or,

with an adapter, into the wall. Add an easy-to-transport enclosure like the old-time radio-style one we built, and it will look great anywhere you need your info fix.—DAVE PROCHNOW



FEED ME Connected to a PC via Bluetooth, the Feeder Reader never lets you miss a new message.

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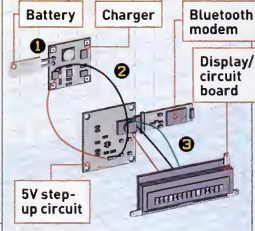
7 HOURS

\$120

EASY  HARD

For more details and a full parts list, go to popsci.com/feeder.

1. Solder the **battery** to the **charger**. Keep the soldering iron below 350°F or you'll overheat the battery's solder tabs.
2. Solder the charger to the input of the **five-volt step-up circuit**. Connect the + and - terminals from the step-up circuit to the **Bluetooth modem** and the **display**.
3. Connect the serial output (labeled "TX-0") from the Bluetooth modem to the display's serial input, and fit the finished assembly inside your custom case.
4. Change your computer's Bluetooth connection port to 9600, 8, N, 1 to make it communicate with the feeder.
5. Download the free LCD Smartie software from lcdsmartie.sourceforge.net. Select the "test driver" display driver, and enter the Bluetooth port and communication settings from step 4. Set the screen size to 1x16. Choose the data that you want to stream, and set the Feeder Reader anywhere within a 50-foot radius of your computer.





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TRUTH IN SPARKS

Cut through titanium-marketing hype—take a grinder to your stuff

IN THE EARLY 1900s, the element radium was so popular, it became a marketing term. Luminous watch hands used radioactive radium, but Radium-brand butter, fortunately, did not. Today, titanium is the new radium. Everything from credit cards to crowbars is advertised as having the strength of titanium. How many products actually do?

As it happens, there is a simple test. Hold any genuine titanium metal object to a grinding wheel (even a little grindstone on a Dremel tool will do), and it gives off a shower of brilliant white sparks unlike any softer common metal. The sparks are tiny pieces of cut titanium—the friction of the grinder heats them till they burn white-hot.

Hold a grindstone to the shackle of a “titanium” padlock from Master Lock, however, and you’ll instead see the telltale fine, long, yellow sparks of high-carbon steel. Shorter yellow sparks show the sides to be a type of stainless steel. Ironically, steel is a better material to make padlocks out of. Titanium is strong and light, but steel is much harder to cut. (Master Lock told me there was a bit of titanium inside, but I couldn’t find it.)

Golf clubs and tennis rackets are ideal applications for titanium, but you can’t tell what’s authentic by sight or feel, and certainly not by the label. One of the two clubs I ground produced no sparks—it was just aluminum, which doesn’t burn.

“Titanium” drill bits and scissors are not made of titanium metal, but they do usually have an extremely hard, low-friction titanium nitride surface coating (which is typically gold in color). The spark test won’t work with coatings, so to analyze two pairs of Westcott-brand scissors, I used x-ray fluorescence spectroscopy at the University of Illinois. Turns out they are, in fact, made from the genuine article.

“Titanium” is such a great word, you can’t blame companies for wanting to associate their products with it. But actually *using* it in their products? Well, maybe that isn’t always convenient.

—THEODORE GRAY

GRAY
MATTER



HOT METAL The titanium bar burns hotter than the steel bolt, producing white sparks when ground.



CAST IRON When held to a grinder, cast iron produces especially beautiful sparks that burst like fireworks.



ALUMINUM No sparks at all means that this golf club, stamped “6061 TITANIUM,” doesn’t contain titanium.



HIGH-CARBON STEEL The long yellow sparks reveal that this “titanium” lock is made of steel, which actually makes for a stronger lock than titanium.



See popsci.com/graymatter/ for a video of this experiment.

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PLUMBING TRICK
OF THE MONTHA LOW-BUDGET
LUXURY SHOWER

INTERPRETING the maxim "Two heads are better than one" literally, college student Dan Poff (danpoff.com) installed a dual shower-head system using leftover copper pipe connected with joints. Then he soldered the whole apparatus to the original pipe from the wall. Both heads get good water pressure, and the entire project cost less than \$15 to build. —HOW 2.0 STAFF

FREE APPLICATION OF
THE MONTH: SPACETIME

The old two-dimensional desktop is over. Download SpaceTime (Windows only; spacetime.com), and transform your computer screen into a dynamic 3-D viewing experience. Do a Google, eBay or Flickr search, and it displays every page that comes up in the results in a neatly organized 3-D stack, enabling you to find what you want far quicker than with a traditional interface.

CAN I USE MY CELL-
PHONE AS A MODEM?

YES, BUT IT MIGHT TAKE SOME WORK. Most phones can connect to the Internet, so it stands to reason that your laptop should be able to link up with your cell via cable or Bluetooth to achieve go-anywhere e-mail and Web access. But the process—known informally as tethering—varies. You can get online via Bluetooth with just a few clicks of the mouse if your phone and computer both support it (Bluetooth isn't as fast as the fastest cellular data networks, however, so the connection may be slow). Otherwise, you may have to get new gear, a new service plan and possibly some new hacking skills.

Take T-Mobile. The carrier doesn't prohibit cellphone tethering, but it doesn't support it either. That means you'll have to go to a site like smartdevicecentral.com if you need any help with setup or operation. At the opposite end of the spectrum, Verizon Wireless offers a \$40 Mobile Office Kit that includes a tethering cable, software and drivers. Connect your phone, fire up the VZAccess Manager software, and presto: You're online, surfing across Verizon's speedy EV-DO network. You will need a new service plan, though. Verizon charges an additional \$15 to \$60 a month depending on your phone model and current plan. AT&T and Sprint offer similar packages and performance.

When he's not tethered to his cellphone, RICK BROIDA covers a wide variety of tech-related subjects for blogs, books and magazines.

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THE 5 MINUTE PROJECT

A MAGNETIC
STUD FINDER*

WHAT: A cheap and easy way to find wall studs

DIY: 1. Tie a string to a strong magnet. 2. Dangle it against a wall, and mark where it sticks to embedded nails and screws. 3. Look for a pattern in your marks—that's where the studs are.

HAVE AN IDEA FOR A 5-MINUTE PROJECT? Send it to us at h20@bonniercorp.com.



*Originally posted on instructables.com

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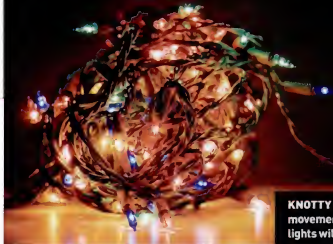
Other glass cleaners contain dyes, scents, soaps, and water. These inexpensive ingredients remove just basic dirt and leave streaky residue, which is difficult or impossible to remove. Invisible Glass contains NO soaps, foams, scents, or dyes. It evaporates quickly and completely, leaving glass clean and clear with NO streaks, haze, or residue.

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Q WHY DO STRINGS OF HOLIDAY LIGHTS END UP IN GIANT KNOTS?



KNOTTY OR NICE? Tangles need movement to form, so shaking your lights will only make things worse.

A A century of research on knot theory has confirmed what every neighborhood house-lighting champion already knows—a string with an unstoppable force of nature. The ingredients of a knot are simple: a string with one loose end, one loop and some movement to push the end through the loop.

Most people coil their lights for storage, which creates several loops for loose ends to dart through as the lights get moved around the garage. Andrew Belmonte, a mathematics professor at Pennsylvania State University, jokingly suggests that one way to avoid the motion that creates knots is to store your lights by hanging them from rafters "like sausages."

Under certain conditions, however, there's no stopping the knots. University of California at San Diego biophysicist Douglas Smith and research associate Dorian Raymer tumbled strings of various lengths one at a time in a box, like a sock in a clothes dryer. Within seconds, each string tied itself into a knot. After

3,000 tosses, the researchers identified 120 types of knots, and their computer simulations predicted that if the experiment continued indefinitely, they would create an infinite number of super-complex knots. The lesson learned: Shaking your tangled mess in frustration will only make a bigger, bulkier knot.

Yet the experiment also revealed a surprising method for preventing knots from forming. When the strings were packed snugly in the box, the knots were much less severe. "There has to be a little motion to make knots," Smith says. "It's not magic."

So if you don't have rafters for the sausage-hanging option, follow these simple storage steps: Eliminate loose ends by plugging the two ends of each strand into each other, box them in a tight squeeze, and put them in a spot in your garage where they won't get jostled. You might be pleasantly tangle-free next holiday season.—COREY BINNS



POPSCI

Send your questions to fyi@popsci.com.

Q Why does coffee, which smells so good, make my breath stink?

A Coffee, it turns out, transforms your mouth into the ideal breeding ground for pungent bacteria. Like other acidic beverages, such as alcohol and lemonade, coffee dries out your mouth. With less antibacterial saliva to keep the bacteria in check, they reproduce willy-nilly. As metabolic by-products, these bacteria emit hydrogen sulfide, which is the main cause of halitosis.

You're only making matters worse if you take your coffee with milk and sugar. Bacteria love eating both, and sugar also feeds plaque-forming (yet non-fragrant) bacteria under which

the malodorous bacteria hide.

If giving up your morning mocha just isn't an option, then try rinsing your mouth with water after you finish your coffee, suggests Harold Katz, founder of the California Breath Clinics. "Saliva does this naturally," he says. "But eating an apple or some celery is also good—they are rough foods with lots of water, which is good for cleaning your mouth."

Cinnamon gum is another effective breath freshener, but not just because its scent masks the stench. Microbiologist Christine Wu of the University of Illinois at Chicago College of Dentistry found that Wrigley's Big Red chewing gum, which contains a negligible amount of sugar, kills up to 50 percent of mouth bacteria thanks to the antibacterial properties of cinnamon oil and other natural flavor oils.

—GRAEME STEMP-MORLOCK ▶

BOOKS

Banana

The banana is sick, and the prognosis is grim: extinction. Today's Cavendish banana—which emerged as the predominant variety after a banana blight in the 1950s—is essentially a clone of the banana you packed in your school lunch bag. In other words, if a fungus kills one banana, it can kill 'em all. A new strain of Panama disease, the fungus that nearly knocked the banana off produce stands, has emerged. But, as Dan Koeppel writes in his new book, which picks up where his 2005 *POPULAR SCIENCE* article on the topic left off, this time the banana has science on its side. *Banana* takes readers to greenhouses around the world, where botanists are frantically trying to bolster the fruit through selective breeding or by modifying it with genes from fish (yes, fish). Hudson Street Press; \$24



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ASK AN INTERSTELLAR BIOETHICIST

If an astronaut dies on Mars, what should be done with the body?

I CAN SAY with fair confidence that if an astronaut died on a short mission to the moon, the craft would turn around and come back. But it gets thornier if the astronauts are on Mars, or even halfway there—any place where turning back would be inadvisable or even impossible.

There are really only two options for the body: Leave it there or bring it home. My guess is that NASA would make every effort to bring the body home. Returning the body would most likely be incredibly important for the other crewmembers, who would have formed an extremely strong bond with one another during the three-year mission (and although the astronauts chosen for this mission would have such a demeanor that they would be less likely to freak out about sharing

the ride home with a dead body, they may need to undergo grief counseling en route). In addition, when a person dies, his or her body becomes the property of the next of kin, who would have the legal right to ask to have the body returned. NASA would certainly take such a request into consideration.

The cause of death could be a huge factor in the decision. If the astronaut died from falling into a canyon, retrieving the body could put other crewmembers at risk. There's also the extremely remote chance that the astronaut's suit could suffer a breach and he or she could become infected with a deadly organism that could endanger the rest of the crew—and Earth. There is no evidence that any such organism (or any organism at all) exists

on Mars, but there still needs to be a plan in place for this scenario. Without a way to contain its spread, we'd have to leave the body behind. But this in turn raises concerns about contaminating Mars.

PAUL ROOT WOLPE is a psychiatry professor at the University of Pennsylvania and a bioethics adviser for NASA. His opinions on future scenarios are not the official stance of the space agency.



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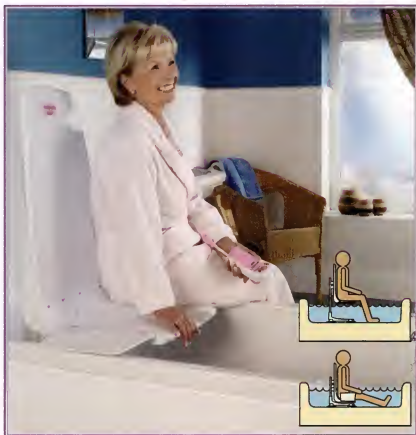
By John Fleming

For many of us, nothing is more relaxing than a long, luxurious bath. Unfortunately, because of safety concerns, many people, particularly older people, have to forego this simple pleasure. Sure, you can spend big bucks to remodel your bathroom to provide a bathtub you can use, but who wants to do that? Now there's a better way, and it lets you use the bath that's in your home today.

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PAGING DR. FEAR

(CONTINUED FROM PAGE 55)

sity who has been experimenting with a drug called propranolol that reduces the intensity of memories in patients with post-traumatic stress disorder. "A memory is preserved in a plastic state. You can sculpt it or update it. Theoretically, any memory, including a fear or declarative memory—being able to say what you had for breakfast yesterday—is capable of being modified."

MAKING THE FEAR PILL

Beginning this fall, in Orangeburg, New York, LeDoux will direct a new research lab, the Emotional Brain Institute, where scientists will comb the brain's molecular networks to search for biochemical clues that might ultimately be used to develop fear-quashing therapies. He won't have any trouble finding test patients. LeDoux gets frequent e-mails and letters from people pleading for relief. "I have phobias, panic disorders, schizophrenia, PTSD—you name it," he says.

Some of research at the Emotional Brain Institute will involve human subjects, and so LeDoux won't be able to use U0126, because it needs to be injected directly into the brain. But there's another compound, an antibiotic called d-cycloserine, or DCS, that already has FDA approval (in higher doses, it's prescribed to treat tuberculosis). The strange thing about DCS is that it works in nearly the opposite way U0126 does—instead of shunting off old memories, it helps the brain to form new ones—but it produces similar results.

DCS stimulates a protein in the brain called the N-methyl-D-aspartate (NMDA) receptor, which facilitates memory formation. When the amygdala is actively embedding a new memory or evoking an old one, NMDA receptors switch on. DCS is like Red Bull for NMDA receptors: It makes them hyperactive, facilitating the formation of new memories. The idea is to create new memories of a given stim-

(CONTINUED ON PAGE 84)



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PAGING DR. FEAR

ulus—a view from a great height, for instance—that lack the traumatic associations of the old memory.

Michael Davis, a professor of psychiatry and behavioral science at Emory University, has conducted some of the first experiments using DCS on humans. Davis gave DCS to patients who had a fear of heights and then outfitted them with virtual-reality (VR) goggles that played a digital video clip simulating the inside of an ascending glass elevator. "The higher they got, the more anxious they got," he says. But over time, their old traumatic memories were overwhelmed by new memories of a benign virtual-reality glass elevator. Compared with those who took the placebo, the DCS patients conquered their fear at a rate of almost 4 to 1.

Davis's latest project is a 300-patient trial that will examine if DCS can alleviate post-traumatic stress disorder in soldiers returning from war. "We have a virtual Iraq, where soldiers are driving their Humvees down the road and there are [explosives] going off," he says. Wearing VR goggles, soldiers are assaulted with the sights and sounds of battle. Before the memories are rekindled, the patients are given DCS in pill form. Neuroscientist Jack Debiec is running a similar trial in association with LeDoux's lab for PTSD-afflicted vets. "Our VR software has visual, audio and tactile components. We also added smells, like smoke," he says. "It's quite realistic, very intense."

But perhaps the most ambitious endeavor is in Atlanta, at Tikvah Therapeutics. Its CEO, Harold Shlevin, a pharmaceutical-company executive who founded the firm in 2006, tells me that Tikvah (Hebrew for "hope") is conducting clinical trials to get FDA approval to use DCS to treat panic disorders, PTSD, obsessive-compulsive disorder (OCD) and "a general catchall category for fears such as snakes, spiders and heights."

Shlevin has

(CONTINUED ON PAGE 86)

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enlisted a company called Virtually Better to create virtual-reality simulations, and he plans to release a DVD that will be packaged with DCS capsules. The DVD would feature simulations to address a variety of fears—the interior of a jetliner, for example, for fear of fly-

ing, or a crowded auditorium with the patient on center stage, for fear of public speaking. For OCD, Shlevin says, “we’d emphasize cleanliness, so we will have them touching a toilet seat.” He expects to market the medication and DVDs to consumers in late 2009 or early 2010;

it will be available on a prescription-only basis from a psychiatrist.

THE CORE QUESTION

Trials like Tikvah’s are designed to answer the most basic questions about using DCS as a fear pill, including dosage and whether it corrupts other memories or cognitive functions. LeDoux suspects that as these move forward, however, researchers will run into some serious troubles. “Complex memories are spread across hundreds of thousands of neurons” through different regions of the brain, LeDoux explains. “The same neurons can participate in many memories.” Just because you can tamper with a fear memory in the amygdala doesn’t mean you’re not mistakenly destroying or adversely altering a memory (or an entire collection of related memories) somewhere else in the brain.

This point is critical. Fear is fused to basic instincts embedded in systems throughout the brain—instincts that evolved over millions of years to protect life and limb. You don’t want to erase a person’s fear of heights only to find out later that he jumped off a bridge believing he could fly. I need to retain the knowledge that some spiders are deadly poisonous even when my fear of them has been eliminated.

It’s certainly possible that eventually we’ll have enough skills to manipulate our own fears, memories and emotions. But according to LeDoux, we won’t reach that point until “we stop thinking of the brain as a bunch of systems and start thinking of it as a system itself.” This conviction betrays a hope for the future of his field—that someday, instead of treating the brain as a collection of dissimilar mechanisms, scientists will approach it (and understand it) holistically. “As individuals we are not the mere sum of our perceptions, fear memories, thoughts and emotions, but synergistically something more,” says LeDoux. “This is the big problem brain research needs to solve—how our brains make us who we are.”

Michael Behar’s last story for POPULAR SCIENCE, “The Prophet of Garbage,” appeared in March 2007.



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CONTINUED FROM PAGE 661

THE GATHERERS

wild plants still exist. But other bean populations grow on private land and are unlikely to survive any future development. "This," he says, "is the sort of race gene banks are in."

A SOLVABLE PROBLEM

Svalbard and its missionaries—Guarino, Street, Debouck, Fowler and the rest—are, in a sense, working to protect us from ourselves. "What's the biological basis for agriculture?" asks Steiner of the Gates Foundation. "It's in the diversity. Nature has been experimenting for millions of years, developing all these species designed for particular ecosystems. Agriculture is very local. At the end of the day, in most places monoculture isn't the most sustainable way."

Even Ethiopia's crops are now threatened by industrial farming. Tewolde Berhan Gebre Egziabher, the director general of Ethiopia's Environmental Protection Authority and a frequent representative for all of Africa on international treaties, believes his country is at a crossroads in terms of protecting its traditional crops. "Now that humanity has begun to learn of the loss of modernizing without protecting genetic resources," he says, "it's time not to make that mistake here."

"This is the only world problem we know we can solve at this point in history," Fowler agrees. "There's no clear solution for some things, like climate change, and the price tag [for that] is incredible. But for a rather limited amount of money, we can actually solve this one."

Despite the abundance found in the Addis market, much of Ethiopia lives on what Guarino calls "the knife edge." One bad year can be devastating. As he drives us back through the countryside south of the city, where donkeys are more plentiful than trees, he gestures around him. "Say someone gives them a hybrid crop, they grow it, and it does well for a few years," he says. We pass a group of barefoot boys, some wearing threadbare business suits over T-shirts, guiding ox plows across brown fields. "So now they've largely lost their old seeds, but then there's a drought or something and the new crop can't survive. And they've got nothing else."

Only a network of gene banks, with Svalbard as the backup, offers insurance against disaster. Vavilov's students believed their work was important enough to die for, Fowler points out. Svalbard is built in that spirit. "They thought the world was going up in flames," he says, "and this would be the seeds from which the world would be resurrected."

Hillary Rosner, a contributor to Al Gore's book An Inconvenient Truth, writes about science for the New York Times and other publications.



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Winnifred Cutler, creator of 10X and 10:13

ABC's 20/20 "SPEED DATE" TEST SHOWS ATHENA PHEROMONES CAN INCREASE SEX APPEAL

MESSAGE FROM DR. CUTLER

Dr. Cutler has a Ph.D. in biology from University of Penn, post-doc at Stanford. Co-discovered human pheromones in 1986 (Time 12/1/86; and Newsweek 1/12/87).

When ABC 20/20's television crew came out to Athena Institute to interview me, I had no idea of what "test" they might perform on my two pheromone cosmetics. And I did not suggest one. When I saw their 12/9/05 telecast, I found out. ABC 20/20 cleverly picked a "speed dating" contest with identical sets of twins.

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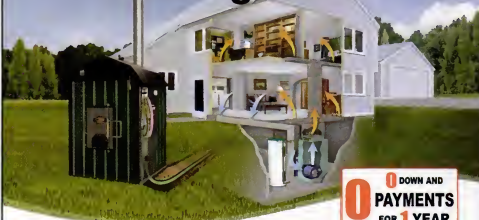
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Since we are engineers, not doctors, we keep the letters and medical reports. One of the worst cases (the report from the oncologist is on file): The man had inoperable colon cancer, tumors on the lung (lung cancer) and lesions in the liver. This

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man was lucky because the man's wife is in the medical field and knew about our machines. You can see on the medical chart because of the increased energy and blood flow: The moment the water got into the blood stream the CEA marker went down even before they started to treat him and every time they gave him a CAT scan the tumors became smaller until they disappeared! After breaking down the hydrogen bonds, cancer cells can't survive in a high blood oxygen environment. Also, when you open up the bond angle your blood can circulate more oxygen coming into your lungs. Oxygen is coming in from two sources! That's why the CEA marker quickly drops! This also helps emphysema!

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Male Enhancement Pills...

Is it a Hoax or Do They Really Work?

Dr. Daniel Stein, M.D.

I wish I had a dollar for every patient or person that asked me over the last few years about increasing the size of "that certain part of the male body." The preoccupation with size that men have is a mystery to most women. The fact is it is completely normal for most men to want to be larger. It doesn't matter if they are smaller than average, average, or larger than average. It's even been my experience that guys that are almost too big, so big in fact that many women won't go near them with a ten foot pole (sorry about that) still want to be larger!

I was so intrigued by this fact that I started to do research about the "so called" male enhancement pills that came on the market several years ago. The concept that a simple pill could noticeably increase the size of a man's organ seemed plausible, but I wanted to know more. I had done much research over the years about certain sexually enhancing compounds available, so I believed the concept was sound that a pill could be made to make a man larger.

My first task was to look at some of the ads I had seen in magazines for male enhancement. There were some amazing claims by many of these makers. My personal favorite was a cream that claimed to make men instantly larger. I had to laugh out loud when I read what it said. The ad read, "apply cream, rub vigorously, increase your size." I thought for a minute and then decided you could put virtually anything on a man, including guacamole, and if he rubbed vigorously it would increase his size. Then there was an ad for a pill, that if taken daily, would increase the length of a man by 3 to 4 inches in just a few short days (sorry about the "short" comment).

I'm sorry, but after all those years of medical school, I know enough about anatomy to know that a guy who is 5 inches in length isn't going to add 3 to 4 inches to his little friend unless he buys a rope, gets a large brick, finds a bridge and...well, you get the picture. At about this time I was beginning to think that perhaps these makers hadn't found the magic mixture of compounds I had hoped they might have.

As the founder of both the Stein Medical Institute and the Foundation for Intimacy, I have spent most of my adult life trying to improve men and

convinced that their product really worked, and they claim to have sold over 100 million capsules to men all over the world. "Over 100 million capsules taken by men." With that single declaration, they had my interest. Either Extenze really worked or these guys were the world's greatest snake oil salesmen. So I requested that they send me Extenze formula so I could review it, then we would talk.



I then visited the Extenze.com web site, where I found a page that showed the top twelve adult film stars, all holding Extenze and endorsing it. I thought to myself, "Is it possible Extenze actually works?"

The next day I received the proprietary Extenze formula and there it was, virtually all of the ingredients that I hoped would be in a male enhancement product, 19 pharmaceutical grade nutraceuticals. There was Yohimbe (which used to be available by prescription only,) L-Arginine, Maca...all of it was there.



I contacted the makers of Extenze the very next day and asked them what they needed me for. They explained that they had a desire to have a medical doctor in their T.V. commercials to talk about the effectiveness of the ingredients in Extenze. At that moment an idea sprang into my head. I told them if they would let me improve the formula of Extenze, I would do the commercial for free!

Before I knew it I was working with their

"they claim to have sold almost a quarter of a billion capsules to men."

chemists at the manufacturing plant where we added the most revolutionary thing to the formula of Extenze. We added DHEA, also known as the "mother of all hormones." DHEA is the most important human prohormone and is the prohormone that converts into testosterone in men. DHEA levels decrease with the aging. Production peaks in a man's early 20's, and declines about 10% every 10 years. Low levels of testosterone can lead to low sex drive and a smaller sex organ.

After a few more weeks of tweaking the formula of Extenze, we were done. The new Extenze formula has been selling even better than the old formula, with over 75% of sales to repeat customers. Extenze has been on the market for 7 years and has sold almost a quarter of a billion capsules to men all over the world. It doesn't matter if you're 18 or 80 years old. In my opinion Extenze can make you larger, harder and increase both your intensity and pleasure and it is as simple as taking a single tablet daily. Extenze is so sure it would work for anyone that they're sending out a free one-week supply of Extenze for nothing more than the cost of a postage stamp. You can contact them directly at 800-799-1643. I recommend any man healthy enough to engage in sexual activity should try Extenze. You have nothing to lose but a lot to gain. ★

"a simple pill could noticeably increase your size."

women's sexual health. I pride myself on being the best medical doctor I can be and my reputation is important to me. So, when out of the clear blue sky, I got a call from the makers of Extenze, the leader in male enhancement, wanting me to be in one of their TV commercials, I thought, "Boy, did they pick the wrong guy!"

Little did they know that I had done real research into this concept and had recently looked at some of these male enhancement products. But the makers of Extenze seemed to be genuinely

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1. Publication Title: Popular Science; 2. Publication No. 577-250; 3. Filing Date: 10/10/07; 4. Issue Frequency: Monthly; 5. No. of Issues Published Annually: 12; 6. Annual Subscription Price: \$19.95; 7. Complete Mailing Address of Known Office of Publication: Bonnier Active Media, 2 Park Avenue, New York, NY 10016; 8. Complete Mailing Address of Headquarters or General Business Office of Publisher: Bonnier Corporation, 460 N. Orlando Ave., Suite 200, Winter Park, Orange County, FL 32789; 9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor: Publisher: Gregg R. Hano, Bonnier Active Media, 2 Park Avenue, New York, NY 10016; Editor: Mark Jannot, Bonnier Active Media, 2 Park Avenue, New York, NY 10016; Managing Editor: None; 10. Owner: Bonnier Corporation, 460 N. Orlando Ave., Suite 200, Winter Park, Orange County, Florida 32789, Terry L. Snow, P.O. Box 8500, Winter Park, Orange County, Florida 32790; 11. Known Bondholders, Mortgagees, and Other Securities: None; 12. Tax Status (for completion by nonprofit organizations authorized to mail at nonprofit rates): Has Not Changed During Preceding 12 Months; 13. Publication Title: Popular Science; 14. Issue Date for Circulation Data Below: September 2007; 15a. Total Number of Copies: 1,586,750 (September 2007: 1,706,169); b. Paid and/or Requested Circulation: (1) Paid/Requested Outside-County Mail Subscriptions: 1,178,524 (September 2007: 1,286,061); (3) Sales Through Dealers and Carriers, Street Vendors, and Counter Sales, and Other Non-USPS Paid Distribution: 150,558 (September 2007: 134,975); c. Total Paid and/or Requested Circulation: 1,328,582 (September 2007: 1,421,036); d. Free Distribution by Mail: 58,593 (September 2007: 13,771); e. Free Distribution Outside the Mail: 17,570 (September 2007: 37,071); f. Total Free Distribution: 76,163 (September 2007: 50,842); g. Total Distribution: 1,404,745 (September 2007: 1,471,878); h. Copies not Distributed: 182,005 (September 2007: 234,291); i. Total: 1,586,750 (September 2007: 1,706,169); j. Percent Paid and/or Requested Circulation: 94.58% (September 2007: 96.55%).



"The Amazing Exercise Program That Transforms Couch Potatoes into Super-Hero Fitness Machines"

It doesn't matter how OLD you are. It doesn't matter how out of shape you are. **Combat Conditioning** will turn your life around.

By Matt Furey

Best-selling author of **Combat Conditioning**

I was the total skeptic. Not only had I lifted weights and run long distances for years, but I had major success under my belt, including a world kung fu championship and a national collegiate wrestling title.

So I just didn't want to believe what Karl, a 76-year-old man told me about exercising **WITHOUT** weights... and **WITHOUT** long-distance running.

Most importantly, I didn't want to hear that a good exercise program only took a few minutes. Hate to admit it, but I was addicted to the "hard work or nothing" mentality and refused to believe you could get into the best shape of your life by doing LESS... not more. Let me tell you, when I looked at this so-called "old man's" physique and watched him demonstrate his exercises, I could not look the other way. I had to check them out for myself, even if it meant saying, "Okay, I've wasted a lot of time doing it the wrong way."

What I discovered shocked me from head to toe!

Before I met Karl I **THOUGHT** I was strong. I thought I was tough. But the exercises he gave me exploited every weakness that weights and running could not cover. In a matter of minutes, I knew Karl "had me."

So I gave up the weights and began a routine of bodyweight calisthenics called **Combat Conditioning**. After all, when a man of 76 can do things that a 36-year-old cannot do, that tells you that "Yes, there's gold in them there hills."

The exercises I learned had such a profound and dramatic effect on me, that for six years I have been introducing men and women of all ages and of all backgrounds to this extraordinary program – and the results are shocking, awe-inspiring and **PROOF** that this system works, and works **FAST**.

Who is Combat Conditioning for?

It's for the hard-working man or woman who often finds it difficult to squeeze in a quick workout.

It's for the traveling executive who sleeps in hotel rooms more than at home.

It's for those who have trained their whole lives on weights.

It's for athletes, martial artists and the military.

And... **IT'S FOR** the man or woman who hasn't done a lick of exercise in decades.

Even One Minute a Day Brings Results!

Unlike other exercise programs where you are told you MUST do 30 minutes of cardio per day and an hour of weights, to get results, **Combat Conditioning** is totally different. 15 minutes is all it takes to whoop the hardcore trainee. But for the total beginner, he or she can get results starting with **ONLY** one minute a day. And no, this is not a joke.

Time is not the issue!

Forget all those workouts that take all day. With **Combat Conditioning**, all that's required is your own

body and a tiny "get started NOW" decision to DO a little something each day.

The key to your success is in the magical, transformative power of these exercises – not in your belief system about hard work. For many people, just one rep is all they can do at first, and they're shaking like a leaf on a windy day in Chicago. And so, that's all that person should do at first. Even if you think you're not doing enough – the exercises work their magic anyway. Your body has its own intelligence and will work **FOR YOU** if you'll simply get out of the way and let it.

When you do, pretty soon you'll be the type of person who can do 2, 4, 8, 16, 32, 64 or 128 repetitions and feel no fatigue. Instead of tiredness you'll feel exhilaration and **ENERGY**. You're building strength and endurance from the **INSIDE-OUT**. And believe me, once you can do more than a few reps, inches of unsightly fat and pounds of excess flab will fly off your body at break-neck speed.

New Results from Forgotten Exercises

Are the exercises in **Combat Conditioning** NEW? Well, not really. They go back about 5,000 years – but for the most part, they got lost in the shuffle when weights, gadgets and gyms came around. So although they aren't NEW, they're "New to YOU!"

Before I learned these exercises, I read about the Great Gama of India, a wrestler who followed this program and was unbeaten in 5,000 matches. I also read that the legendary Bruce Lee did these exercises, too. And we all know about Lee's incredible martial arts skills. Then there was the All-Pro NFL running back, Herschel Walker, who did bodyweight exercises each day. The list goes on and on. The key is in having a proven program with a track record, and **Combat Conditioning** is just that.

Puts You into the Old Clothes You Dream of Wearing Again!

The main reason why **Combat Conditioning** works is because it targets all the weak links in your body. And when all those weak links are given a little attention, your entire body gets stronger, faster, more powerful and more energetic. Spend time each day doing a few functional exercises and the payoff is **HUGE**.

You get functional strength, endurance and flexibility – all at the same time. Not to mention seeing the excess inches flying off your body, making it easy for you to fit into the clothes you dream of wearing again. Stop dreaming. Start **DOING**. And get results.

12 Ways Combat Conditioning Will Change Your Life!

Follow this program and your body is going to change big time. In fact, I've made a list of 12 of the most powerful benefits that hundreds of thousands of others all over the world have gotten from the **Combat Conditioning** program. Let's take a look:

1. Cranks up your metabolism so you

burn excess body fat a lot, lot faster. This means fitting into the clothes you **WANT** to wear.

2. Packs attractive and healthy functional muscles (not grotesque) onto your entire body
3. Simultaneously doubles your strength and flexibility – and does so without needing separate workouts for each.
4. Quadruples your endurance inside of 30 days. Never get tired again.
5. Within a couple weeks, it often eliminates chronic back and shoulder pain from years of heavy squats, deadlifts and bench pressing – or other forms of abuse.
6. Sleep like a log. Eight hours of deep sleep is no longer a goal. It's automatic. As soon as you hit the rack you're out like a light.
7. Your self-confidence will have no bounds. Especially when you got compliments from people who hardly paid attention to you before.
8. You can train anywhere. You don't need more than a few square feet of carpet or pavement and you're all set. You don't need equipment. Just your own bodyweight.
9. You get a kick-butt workout done in 15 minutes or less.
10. You'll turn back the clock. Friends may tell you that you look 5-10 years younger.
11. You'll have an explosive type of strength that weights cannot give you. Your every movement will be lively and full of vigor.
12. Your muscles will be pliable and powerful, like a tiger's.

Here's How to Order

Combat Conditioning: Functional Exercises for Fitness has 48 super effective bodyweight exercises along with seven different programs that will get you into kick-butt shape fast. Order NOW and you'll receive 3 free Special Reports on how to eliminate knee, back and shoulder pain. Your total investment in this no-nonsense book is only \$29.95 plus \$6 S&H U.S. (foreign orders add \$12). Order online at www.mattfurey.com.

Or pick up the phone right now and call 1 813 994 8267 to order. You can also send a money order to Matt Furey Enterprises, Inc., 10339 Birdwatch Drive, Tampa, FL 33647.

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Matt Furey

won a national collegiate wrestling title in 1985 and a world shuai-chiao kung fu championship in 1997. Furey has a knack for taking the average and ordinary person and transforming him with his powerful programs. Furey was inducted into the Edinboro University Athletic Hall of Fame in 1998 and spends much time each year traveling throughout the world, searching for the very best information available in his world-wide audience. His website, www.mattfurey.com, is one of the finest in the world, giving valuable information that changes lives.

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(DBSDEP) Will the FDA clear deep-brain stimulation as a treatment for clinical depression by September 30, 2008?

As bizarre as it may sound, an electrode implanted deep in the brain can relieve otherwise intractable cases of depression. The technology is still experimental, but it could go mainstream soon. Exactly how soon is the question. Stage-2 clinical trials are in progress, and DBS is already FDA-approved for treating motor disorders, which is probably why the market is so upbeat.



(HELMET) Will the NFL give its players concussion-sensing helmets by the beginning of the 2008 season?

Concussion-induced brain damage and dementia are increasingly common concerns for former pro football players. Fortunately, sensor-embedded helmets that tell sideline coaches whether a player has sustained a concussion-level hit already exist. Will the NFL start using them this year? The market believes it's likely.



(ARCOIL) Will oil from the Lomonosov Ridge, the Beaufort Sea or the Chuckchi Sea be packaged for export by January 1, 2010?

Most people agree that the melting of the Arctic ice cap is not a good thing. Then again, most people aren't oil tycoons. Nearly every nation with any claim to Arctic resources is now rushing to secure oil rights in newly thawed territory. Drilling is inevitable—but how soon will it happen? PPX traders expect to be burning polar gasoline in two years or less.



NEW YEAR, NEW STOCKS TO WATCH

A sampling of the stories the PPX will track in 2008



(GTAIV) Will Grand Theft Auto IV be the best-selling game of the year?

The fourth installment of the controversial hit game, which arrives mid-2008, is expected to outsell its predecessors—but can it beat Halo 3 and Madden?

(EADSPLN) Will EADS start construction on a tourist rocket by December 31, 2007?

The European aerospace giant's entry into the private space race shows that big players are starting to take space tourism seriously. But will EADS build a rocket-plane as soon as it says?



(CNGSTN) Will a U.S. city of one million or more adopt congestion pricing by January 1, 2009?

London's solution to smog and gridlock: Charge drivers to enter the city. New York could follow suit. Will anyone pull the trigger?



(BEEBACK) Will honeybee colonies fare better in 2008 than in 2007?

Honeybees pollinate 15 percent of the plants we use for food—and last year, bees died in droves. Anxious scientists and farmers are eager to see improvement this year.

WHAT IS THE PPX?

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